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OCTOBER 2007

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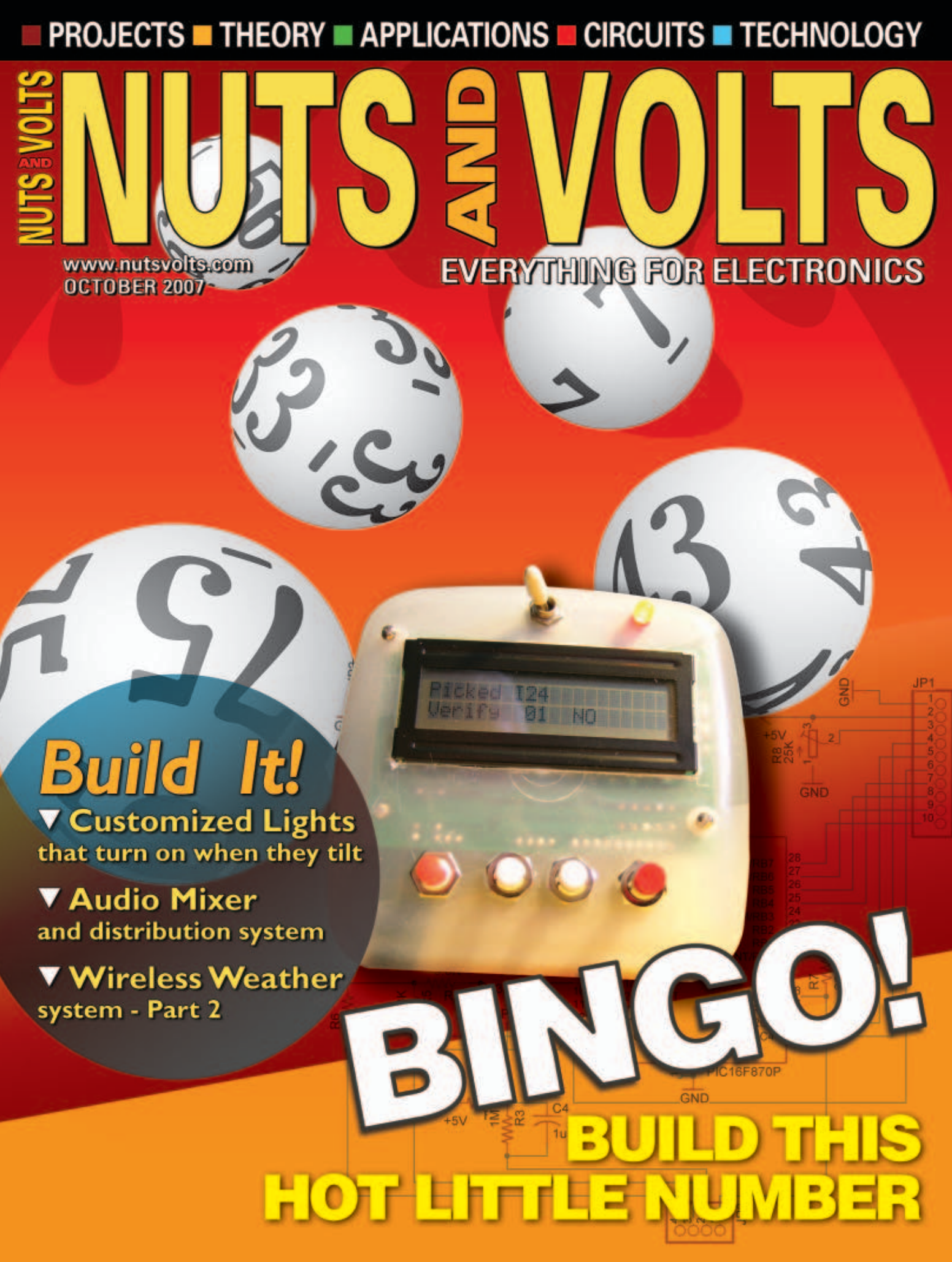

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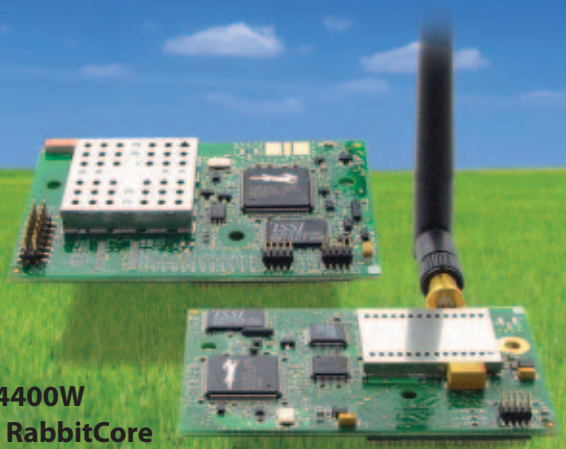

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NUTS AND VOLTS

OCTOBER 2007

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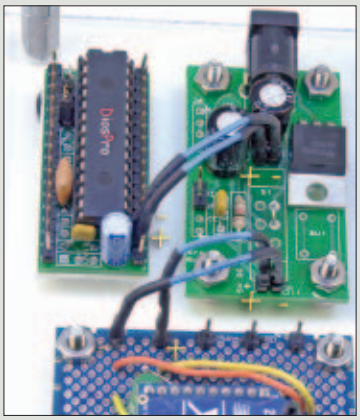

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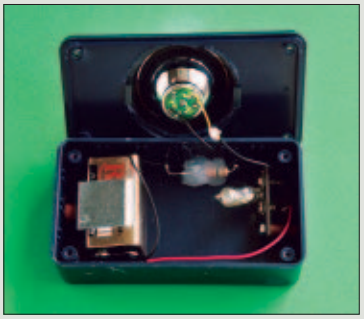

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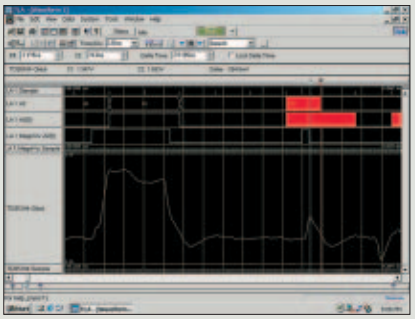

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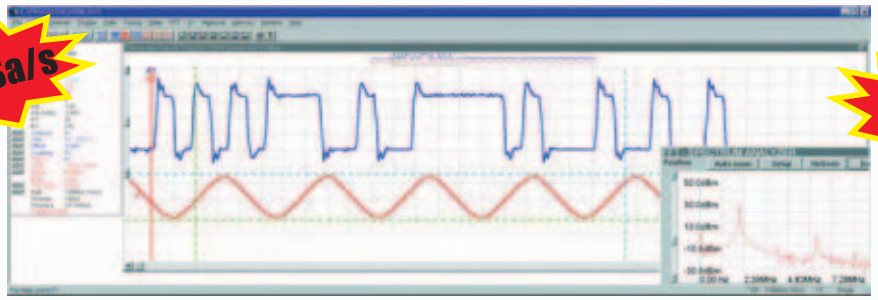

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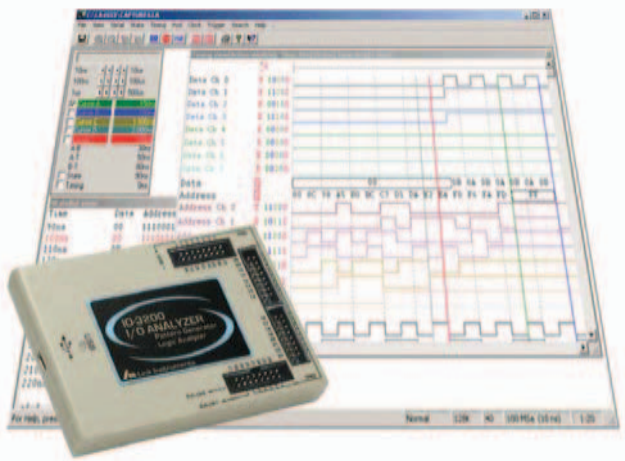

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DEVELOPING PERSPECTIVES

by Bryan Bergeron, Editor

In this issue of *Nuts & Volts*, we're fortunate to feature several excellent articles, including Jeff Mazur's introduction to digital broadcasting and Paul Kafig's discussion of the discrete Fourier transform (DFT). Both topics represent sea changes in the evolution of electronics, but through very different mechanisms.

Change has been slow in the move to digital broadcasting because of the inertia associated with the installed base of analog receivers and transmitters. Digital broadcasting has several advantages over the analog broadcasting infrastructure built over the past half century, including obviously superior image and sound quality, the ability to multicast, and support for interactive video and data services. Despite these and other advantages of digital broadcasting, it's difficult to convince a consumer with an inexpensive, fully-functioning analog TV receiver to part with several hundred dollars for a new digital receiver system or even purchase a less expensive converter.

Similarly, the owner of a broadcast station with tens of thousands of dollars invested in analog equipment would like to be able to attract additional advertising revenue to cover the cost of a digital upgrade. However, because the FCC has set the final transition date of February 2009 for the move from analog to digital broadcasting, broadcasters must either fold or convert. After February 2009, the current analog channels will be put to other use.

The DFT, in contract, is an enabler of the practice of modern, computer-based electrical engineering. Digital signal processing and related operations that make digital broadcasting possible would be impractical without the fast Fourier transform (FFT) and related algorithms used to compute the discrete Fourier transform. Unfortunately, the gulf between the frequency and time domains is more than simply perspective, but is one of facility with higher math. Electrical engineering students are introduced early on in their training to matrix algebra and other forms of higher math used to define the DFT. In contrast, technicians, hobbyists, and experimenters typically develop an intuitive, time-based understanding of signals.

Fortunately, it doesn't require higher math or the ability to reason in the frequency domain to be able to apply the DFT to applications ranging from spectral analysis to data compression. Of course, it's useful to understand the limits of the DFT used in a particular oscilloscope/spectrum analyzer, for example, so that you know when to trust the measurements and when to suspect — and how to test for — instrument error.

If you're not comfortable shifting between the frequency and time domains in your design and debugging work, consider broadening your horizon by studying the DFT and related mathematics. There are many experimenters who are content to work with vacuum tubes and discrete transistors, leaving digital circuitry and DSP techniques to other enthusiasts and formally trained engineers. However, that approach is limiting.

Although the FCC won't demand you learn digital signal processing techniques using the DFT by a given date, you are free to establish your own deadline. In addition to reading the DFT series in *Nuts & Volts*, consider some of the better DFT sites on the web, such as Julius Smith's Mathematics of the DFT at Stanford's Center for Computer Research in Music and Acoustics, **ccrma.stanford.edu/~jos/mdft/**. Give yourself a few months to absorb the material and concepts. When you're done, you'll have a new appreciation for the frequency domain and the myriad applications in electronics. **NV**

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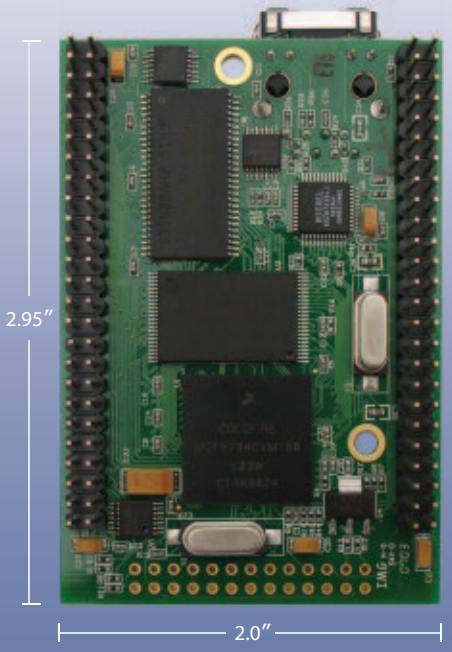

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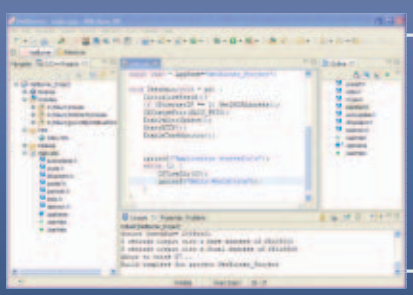

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READER FEEDBACK

NUTS AND VOLTS
EVERYTHING FOR ELECTRONICS

A MORE DIRECT LINK

On page 26 of the August '07 issue, it is mentioned by Russell Kincaid to go to the link at **www.linear.com** and get a copy of the LT Spice sim software ... well, it is a bit difficult to find! Here is the direct link: **www.linear.com/designtools/software/index.jsp**.

You will find other goodies, as well.

Teddy

CHARGED UP OVER GOING GREEN

I thought the new "Green Power" section in the August edition was an excellent idea. I hope to see this section in future copies. "Going green" has never been a more timely and important subject than right now.

I am currently studying fuel cell technology. I have stumbled across some "how-to" articles from the mid-nineties. I would love to see a current version of this subject covered in *Nuts & Volts*.

Travis Crose

DOESN'T SEE THE CNC

I just received the July issue of *Nuts & Volts* magazine. For the last few months, I have been working on a project to build a 3D laser scanner. I have most of the hardware built and am now working on the software side of things. So, imagine my surprise and relief when glancing through the table of contents, I discovered the article entitled "Introduction to 3D Scanning" by Dan Mauch along with the description "Learn how to make 3D scans at a fraction of the normal cost."

I turned to page 74 and started reading in great interest only to discover the article was basically a three page ad for a kit from Camtronics-CNC.

Where is the nuts and volts of this article? I was expecting an article about the hardware and software required to perform this task. I was disappointed and will approach articles in the future with more caution.

James Weikle
Claremont, NC

OFF THE RADAR

In the August '07 issue of *Nuts & Volts*, I was surprised to see the published Tech Forum answer to #6071 that stated that "Most all grocery door sensors are PIR." Maybe that is true in Kansas, but in south Florida, most are radar. Anyone with a radar detector who lives in this area knows this is true. Many

Continued on page 93

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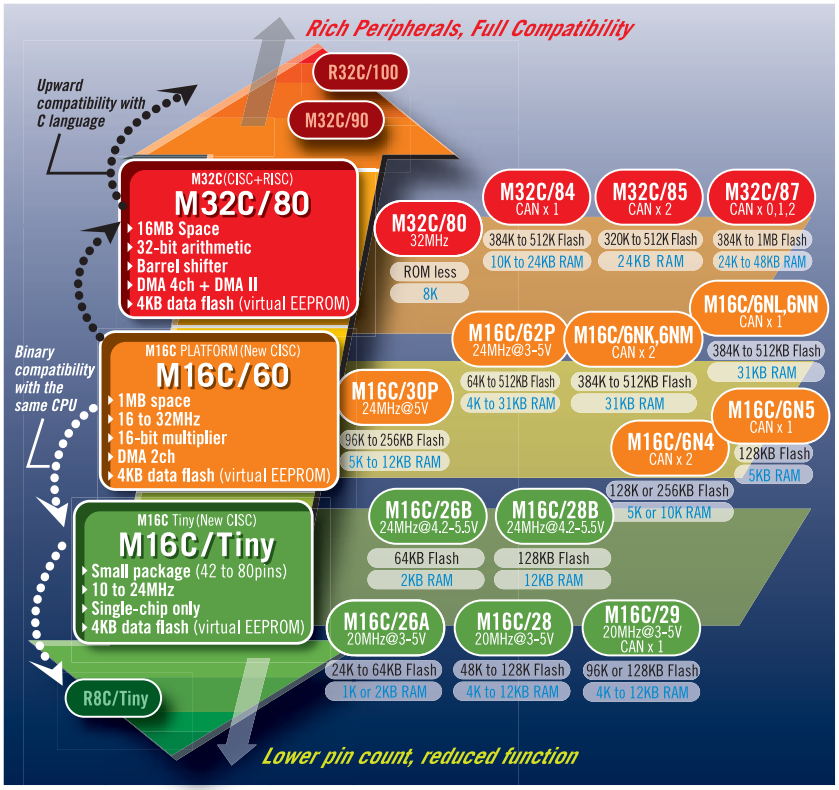

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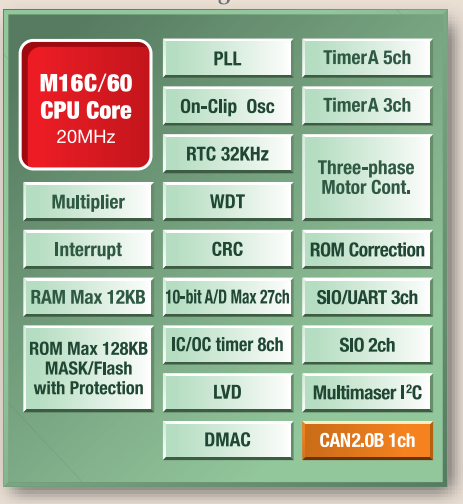
M16C/29 Block Diagram



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*Source:Gartner Dataquest (April 2006) "2005 Worldwide Microcontroller Vendor Revenue" GJ06333

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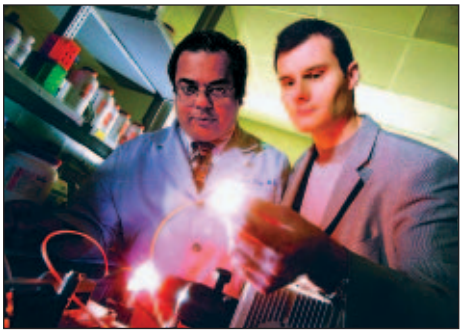
TECH KNOWLEDGEY 2007

EVENTS, ADVANCES, AND NEWS

■ BY JEFF ECKERT

ADVANCED TECHNOLOGY

DETECTING CANCER WITH LIGHT



■ Vadim Backman (right) and Hemant Roy demonstrate a portable version of the new spectroscopy tool.

PHOTO COURTESY OF NORTHWESTERN UNIVERSITY, EVANSTON-NORTHWESTERN HEALTHCARE.

Pancreatic cancer presents few obvious symptoms and is notoriously difficult to detect. In addition, the pancreas can become dangerously inflamed by standard inspection techniques, so it is not routinely examined. As a result, more than 33,000 people in the US died of the disease last year. But a team led by engineering Professor Vadim Backman, of Northwestern University (**www.northwestern.edu**), has come up with a new approach that appears to provide highly effective and minimally invasive early detection. It is based on a combination of "elastic light-scattering" and "low-coherence enhanced back-scattering" techniques that Backman et al. have developed over the past five years.

The process involves taking tissue samples from an adjacent area (in this case, the duodenum), altering the samples, and probing the tissue on a submicron scale. In practical terms, a xenon lamp shines intense, white light through a series of lenses and filters onto the specimen. The light refracts through it and scatters into a spectrograph. An image sensor then collects data for computer analysis.

In a recent test, researchers scanned samples from 19 people who already had been diagnosed with the disease and 32 without it and came up with the right diagnosis in nearly every case.

This builds on previous studies in which the technique was used to examine 500 patients for colon cancer. In this case, researchers predicted, with 100 percent accuracy, the existence of polyps in patients diagnosed with a simultaneous colonoscopy.

Possibly the best news is that it is necessary to scan only the outer few centimeters of the colon, so colonoscopies may soon be a thing of the past. If further research pans out, the instrument may provide similar results with breast, lung, and other cancers. It may be available for clinical use in three to five years.

ANOTHER STEP TOWARD FUSION

Although news agencies and politicians tend to treat power from nuclear fusion as something of a fantasy, it is worth noting that progress continues in the background. Earlier this year, researchers at Sandia National Laboratories (**www.sandia.gov**) announced a development that they uncharacteristically described as "revolutionary."

Sandia's research is based on inertial confinement, which traditionally has been viewed as less promising than the other current approach — magnetic confinement. In the former, a laser pulse is used to compress and heat hydrogen pellets to fusion temperatures, creating a reaction that is confined by the inertia of the fuel itself. In the latter, a continuous reaction is confined by trapping the plasma within magnetic fields.

A drawback to inertial confinement has been that the fusion pulses cannot be created often enough to yield practical amounts of energy. It has been compared to a one-cylinder internal combustion engine that fires only every few hours. But a new system, developed at Russia's Institute of High Current Electronics, has been tested at Sandia's Z machine facility.

Preliminary experiments and computer simulations show that it can reliably produce bursts every 10.2 seconds for millions of cycles, which brings it into the realm of serious consideration. According to Sandia's Keith Matzen, "This is the most significant advance in primary power generation in many decades."

The new system is based on a circuit called a linear transformer driver (LTD), which is basically a switch tightly coupled to a pair of capacitors. When these "bricks" are packed in groups of 20 and connected in parallel, the resulting "cavity" can transmit a current of 0.5

PHOTO BY RANDY MONTOYA.

■ Sandia researcher Bill Fowler tests circuits on an LTD device that produces large electrical impulses rapidly and repeatedly.

mA at 100 kV. (The next-generation system will produce 1.0 mA.)

At last count, a test cavity at Sandia had been fired flawlessly more than 11,000 times. The switch also eliminates the need for hundreds of thousands of gallons of insulating water and oil carried by the present Z structure, as well as (sadly) the highly entertaining electrical arcing over the water's surface.

The next step is to find $35 million over the next few years to build a test bed with 100 cavities. If all goes well, a working electrical generation plant could be as little as two decades away.

COMPUTERS AND NETWORKING

SUN INTRODUCES NEW MICROPROCESSOR

■ The UltraSPARC T2 is billed as the world's fastest commodity microprocessor.
PHOTO COURTESY OF SUN MICROSYSTEMS.

The latest from Sun Microsystems is that the company has entered the commercial silicon market with the UltraSPARC T2, billed as the world's fastest commodity microprocessor. Available separately from Sun's own systems, it offers eight cores and eight threads per core. With each thread capable of running its own operating system, the T2 provides a 64-way system on a single chip.

Developed under the "Niagara 2" program, the processor design will be offered to the free and open source community via the general public license (GPL), and it provides support for the open-source Solaris OS in addition to other real-time operating systems and future versions of Ubuntu Linux.

The device is designed to bring together virtualization, processing, networking, security, floating point units, and memory access on a single piece of silicon, thereby reducing cost and increasing performance, reliability, and energy efficiency. Clock rates range from 900 MHz to 1.4 GHz, which may not sound all that impressive. But marketing director Fadi Azhari noted, "The competition is simply continuing the brute-force method of increasing clock speed and creating trade-offs between performance and power consumption. Sun's approach ... is much more holistic, based on efficient threading and the integration of key functions onto the chip itself."

The T2 can handle up to 64 fully buffered DIMMs using four memory controllers and deliver better than 50 GB/s of memory access. In production now, the pricing starts at less than $1,000 per unit. For details, see **www.sun.com/products/microelectronics**.

SOFTWARE ENHANCES NASCAR

If you don't already enjoy watching cars drive around in circles for hours, this probably won't draw you into the NASCAR realm. But if you are a fan, you will probably enjoy Draft Track, a visualization tool based on an algorithm developed at the University of Washington (**www.washington.edu**). It was originally intended for interactive simulations in video games that would allow players to drive through smoke and fire, interact with weather when running a flight simulator, or drive in a virtual wind tunnel. But it now has been employed by Sportvision, Inc. (**www.sportvision.com**), to enhance NASCAR broadcasts.

■ Visualization software shows speed and direction of airflow over NASCAR vehicles.

PHOTO COURTESY OF ESPN.

The visual enhancement first hit prime time in coverage of the Allstate 400 at the Brickyard race, held at the Indianapolis Motor Speedway last July. The code, which speeds up real-time fluid dynamics simulations, calculates air flow over the cars and displays it as colors trailing behind them. Green, blue, yellow, and red correspond to different speeds and directions, and it can track multiple cars moving at better than 200 mph. So pop open a Bud and enjoy.

NAME-BASED SEARCH ENGINE

Given the beaucoup bucks raked in by Google, Yahoo!, and others, owning a search engine appears to be a highly desirable thing. The problem is that there are already more than anyone needs — unless you can think of a different approach. Enter **www.spock.com** — a site that is specifically geared to people. The beta version was launched in August, and as of this writing it lists more than 100 million people. With millions more added on a daily basis, its creators intend to build "the broadest and deepest people specific search engine," with the goal of eventually indexing "everyone in the world."

It seems to need some refinement, though, and not only because it still can't find me. It zeroed in, appropriately enough, on Leonard Nimoy. But George Washington (the president) showed up behind George C. L. Washington (inventor of instant coffee). You can also

INDUSTRY AND THE PROFESSION

ARGONNE SCIENTIST HONORED

Gian Piero Felcher, a senior physicist who in February retired from Argonne National Laboratory (**www.anl.gov**), was recently named an inaugural fellow of the Neutron Scattering Society of America (**www.neutronscattering.org**). He was selected for "pioneering the development of neutron reflectometry and demonstrating its application to magnetic and polymer film systems."

PHOTO COURTESY OF ARGONNE NATIONAL LABORATORY.

■ Gian Felcher was named fellow of the Neutron Scattering Society.

Felcher worked at Argonne for more than 40 years and in 1984, developed the first polarized neutron reflectometer. In case you were wondering, the society is not made up of people who go around the country tossing out neutrons like Johnny Appleseed. Rather, it provides a link among people from a range of disciplines who have an interest in neutron scattering research. Membership is free, and grad students and recent Ph.D.s are particularly welcome.

NICE DEAL IF YOU CAN GET IT

After presiding over less than stellar financial performance, Dell, Inc.'s, president and CEO Kevin Rollins retired back in May. In a filing with the Securities and Exchange Commission, Dell later disclosed that Rollins received a dandy chunk of severance pay to the tune of $48.5 million in cash. According to the report, he had 7.37 million unexercised stock options, and the company had to buy him out. Founder Michael Dell took back the reins, but the company reportedly is still losing market share to HP and is reducing its workforce. There is no need to worry about Rollins' employment situation, by the way. He recently landed a job as a senior advisor with TGP Capital Partners, a private investment firm in Kansas City.

search by category, and spock suggests such things as "NFL quarterback," "actor," and "executed by electric chair." But a search on "pervert" placed newsman Bill O'Reilly in first place, which is probably undeserved.

In any event, you get a brief bio of the located individuals plus a collection of related links, so it could dredge up some useful information.

CIRCUITS AND DEVICES

AUDIO AMP DRIVER INTRODUCED

PHOTO COURTESY OF NATIONAL SEMICONDUCTOR.

■ National's new single-chip driver provides higher power per square inch of chassis space.

As an addition to its existing family of power amp output stage drivers, National Semiconductor (**www.national.com**) recently launched the model LME49810, a single-chip 200-V unit that sports an integrated Baker clamp (essentially, a bunch of diodes connected around a bipolar junction transistor to prevent saturation of the collector-emitter junction) that replaces more than 25 discretes in the device. It is aimed at high-end consumer and professional audio applications including powered studio monitors and subwoofers, audiovisual equipment, commercial sound reinforcement, mixing boards, and guitar amplifiers. It is designed to drive high-power discrete transistors in systems delivering up to 3,000 W.

In a complete system, the total harmonic distortion plus noise (THD+N) is rated at an impressive 0.0007 percent. Other specs include a slew rate of 50 V/s, a power supply rejection ratio (PSRR) of 110 dB, and an operating voltage range of ±20 V to ±100 V. The devices are available in a 15-lead TO-247 package and run $8.50 in 100-unit quantities.

BAD TO THE BONE?

The folks at Thanko sell some odd electronics on their Internet store (**www.raremonoshop.com**), and one of the strangest is the Vonia EZ-4200P Bone Conduction Headphone. Presented as a means of reducing stress and strain on your eardrums, you clamp the things onto your skull, and sound is conducted to the inner ear through solid bone. The headphones weigh only about 2.6 oz (73.5 kg) and offer sensitivity of 74 dB ± 3 dB. Frequency range is not included in the specs, perhaps because the high end is dampened by the echoes inside the average user's cranial cavity. Anyway, for only $81.67, they can be yours. **NV**

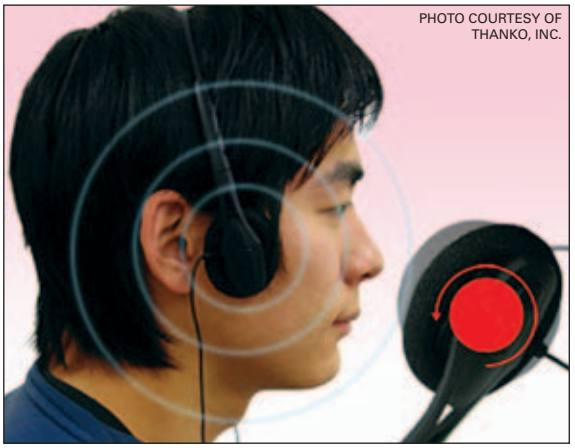


PHOTO COURTESY OF THANKO, INC.

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■ BY FRED EADY

PETER BEST CIRCLES THE DRAIN

NO. IT'S NOT A MISPRINT. Peter has been rotated out of the Design Cycle and into the toilet ... literally! It may comfort you to know that Peter hasn't committed any felonious acts or taken any missteps in the outhouse. Mr. Best has decided to leave his Design Cycle duties and take a position with the Xerolet Corporation. Peter is in the toilet because Xerolet makes potties. However, unlike the dumb (but proud) porcelain monument found in most of our bathrooms, the potties produced by Xerolet are high-tech units designed to be deployed in places devoid of communal waste treatment facilities. You can take a look at what Peter has "fallen into" at www.xerolet.com. And, yes. There are LOTS of potty jokes floating around the EDTP lab these days. I am honored to be able to step in for Peter and we all wish him continued success at Xerolet.

Peter and I worked together on the EDTP Ethernet MINI C-to-PBP (PICBASIC PRO) conversion project that you have been reading about in this series of Design Cycle episodes. So, I'm up to speed and ready to go with this month's MINI driver conversion subject matter. We've already gotten the basic driver stuff up and the latest EDTP Ethernet MINI PBP driver code for ARP, UDP, and ICMP (PING) was put up for you to grab via ftp last month. The PICBASIC PRO MINI code you have access to right now is enough to get the EDTP Ethernet MINI online. However, adding a touch of DHCP to the mix will add some flavor to our MINI stew.

JUST IN CASE

If you're DHCP challenged, Peter presented the details of the innerworkings of DHCP and the embedded coding behind it all in a past Design Cycle column. If the concepts that I am presenting in this discussion are unfamiliar to you, I suggest refreshing your DHCP knowledge by checking out past Design Cycle columns.

DHCP is short for Dynamic Host Configuration Protocol. As Peter pointed out in his DHCP discussions, DHCP is message based and through its services a network client host such as the EDTP Ethernet MINI can automatically obtain IP, gateway, and subnet mask information from a DHCP server participating in the client host's network. DHCP is not difficult to understand, and likewise, is not difficult to code into an embedded application. This month, our goal is to code a PICBASIC PRO-based DHCP engine into the EDTP Ethernet MINI. So, let's get started.

DHCP WITH PICBASIC PRO

We'll need to add some DHCP-specific PBP code modules to our existing PICBASIC PRO-based EDTP Ethernet MINI driver to get DHCP up and running on our EDTP Ethernet MINI hardware. Specifically, at a minimum, we'll need to add a DHCP initialization routine, a DHCP engine routine, a DHCP transmit message routine, and a DHCP receive message routine to our existing code. While we're at it, we'll also code in a routine to allow us to display our received DHCP addressing information on a personal computer running a terminal emulator application. And, if that's not enough excitement for you, we'll throw in some PICBASIC PRO code to broadcast our newly acquired DHCP parameters using UDP and retrieve the UDP datagram using a Microchip PC application called MCHPDetect.

PLANTING THE FIRST DHCP SEED

Before we do anything about building up the aforementioned DHCP modular routines, we'll need to tell our main PICBASIC PRO operating loop about the DHCP stuff we're about to code up. Please consider the following PBP source code snippet:

```
forever con 1
;*********************************************************
;*     MAIN PROGRAM
;*********************************************************
       on interrupt goto int_handler
       OSCTUNE = $40
;*********************************************************
;*     CONFIGURE AND START TIMER2
;*     SET TO OVERFLOW EVERY 1mS
;*********************************************************
       hours = 12
       mins = $00
       secs = $00
       milliseconds = 0
       T2CON = $79
       PR2 = $A3
       TMR2ON = 1
       TMR2IE = 1
       gosub init_EUSART
       gosub init_IO
       gosub init_67J60
       DHCPSTATE = DHCP_ENTRY
       gosub init_DHCP

       while forever
        if EPKTCNT != 0  then
              gosub get_frame
        endif
        gosub dhcp_state_engine
       wend
end
//*********************************************************
```

Nothing in the original MAIN PROGRAM code has changed, but I did take the liberty of adding some DHCP-relative statements. The DHCPSTATE = DHCP_ENTRY PBP statement allows you to enable or disable the DHCP code at compile time. For instance, equating the DHCPSTATE to DHCP_DISABLED will turn the code execution around at the beginning of the DHCP initialization routine init_DHCP that is called following the declaration of the initial DHCP state you desire. You can easily see how this "turn around" mechanism works by examining the simple PBP statements that make up the DHCP initialization code module:

```
;*********************************************************
;*     INITIALIZE DHCP STATE MACHINE
;*********************************************************
init_DHCP:

       if DHCPSTATE == DHCP_DISABLED then
             return
       endif
       dhcpflags = 0
       DHCPSTATE = 0
       DHCPSTATE = DHCP_ENTRY
return
//*********************************************************
```

Once all of the hardware modules have been initialized and the DHCP state has been determined, the EDTP Ethernet MINI driver will loop forever checking for incoming Ethernet frames and servicing the DHCP engine.

If you were able to get your hands on the previous EDTP Ethernet MINI PICBASIC PRO conversion Design Cycle installments, you'll recall that many a C-to-PBP pitfall lies in our path. One of those spiked booby traps involved the way PBP handles SELECT CASE structures versus the way ANSI C treats its native SELECT structures. PICBASIC PRO handles SELECT CASE perfectly in 99.999% of the situations the SELECT CASE statement is involved in. However, although the PBP SELECT CASE statement in its native state doesn't fit well into our DHCP engine code, it seems that the PICBASIC PRO designers were really just trying to help us out. The ANSI C language delimits each case structure within a SELECT structure with a break statement. A C programmer with too many hours behind the keyboard and too much JOLT soda in his or her system may accidentally omit a break statement.

The C program will compile just fine. However, the case structure immediately following the omitted break statement will execute without performing another select operation. That's normally not a good thing. Guess what? It was done intentionally in the EDTP Ethernet MINI C driver code. Here's a code snippet of the original C version:

```
//*********************************************************
//*     DHCP STATE MACHINE
//*********************************************************
void dhcp_state_engine(void)
{
        unsigned int i;
        switch(DHCPSTATE)
        {
              case DHCP_ENTRY:
                    printf("\r\nDHCP RESET..");
                    for(i=0;i<4;++i)
                          tempipaddrc[i] = 0x00;
                    DHCPSTATE = DHCP_INIT;
              case DHCP_INIT:
                    printf("\r\nDHCP INIT..");
                    for(i=0;i<6;++i)
                          svrmacaddrc[i] = 0xFF;
                    for(i=0;i<4;++i)
                          svridc[i] = 0xFF;
                    msecs_timer = 0;
                    DHCPSTATE = DHCP_WAIT;
              case DHCP_WAIT:
                    if(msecs_timer >= 2000)
                          DHCPSTATE = DHCP_BROADCAST;
              break;
//*********************************************************
```

Note the absence of the break statement between the DHCP_ENTRY, DHCP_INIT, and DHCP_WAIT case structures in the preceding C code snippet. Intentionally omitting the break statements causes the trio of case structures to execute one after the other until a break statement is encountered. That may be clever in C, but it's impossible to do in PICBASIC PRO. Accidental elimination of break statements within SELECT CASE structures is just the thing I believe the PICBASIC PRO designers are protecting us from. That's one we should add to the Universal Rules of Computing: "You can't screw it up if you can't code it."

Since we can't override the absence of SELECT CASE break statements in PBP, we'll have to emulate the original DHCP engine code as best we can with the tools that PICBASIC PRO provides. As you can see in the PICBASIC PRO code snippet that follows, the ported PBP DHCP engine code converts the original EDTP Ethernet MINI C

DHCP engine code's SELECT structures to standard PBP if-then structures:

```
;*******************************************************
;*     DHCP STATE MACHINE
;*******************************************************
dhcp_state_engine:

            if DHCPSTATE == DHCP_DISABLED then
            return
            endif

            if DHCPSTATE == DHCP_ENTRY then
                  hserout[13,10,"DHCP RESET.."]
                  for i8 = 0 to 3
                        tempipaddrc[i8] = $00
                  next i8
                  DHCPSTATE = DHCP_INIT
            endif
            if DHCPSTATE == DHCP_INIT then
                  hserout[13,10,"DHCP INIT.."]
                  for i8 = 0 to 5
                        svrmacaddrc[i8] = $FF
                  next i8
                  for i8 = 0 to 3
                        svridc[i8] = $FF
                  next i8
                  msecs_timer = 0
                  DHCPSTATE = DHCP_WAIT
            endif
            if DHCPSTATE == DHCP_WAIT then
                  if(msecs_timer >= 2000) then
                        DHCPSTATE = DHCP_BROADCAST
            endif
      goto breaker
//////////////////////////////////////////////////////
breaker:
return
//*******************************************************
```

Using consecutive if-then PBP structures allows us to emulate the "breakless" C SELECT constructs. When a break of execution is required, the much C-programmer-maligned BASIC GOTO statement is brought into action. You can use GOTO in many C compiler implementations but odds are you'll never see a GOTO used in a serious C application. I must admit that I tend to avoid using the GOTO statement at all and I was really pulling for straws when I coded it into the PICBASIC PRO EDTP Ethernet MINI driver. The line of forward slashes (///) in the preceding PBP code snippet represents the rest of the dhcp_state_engine subroutine statements. The breaker label lies at the end of the dhcp_state_engine subroutine.

Other than the SELECT emulation, the rest of the dhcp_state_engine subroutine port was logical and straightforward. As you can see in the preceding code snippets, the C printf statements map easily to the PBP hserout statements. C-to-PBP if-then and for-next structures were also easy ports.

Another C form that is not native to PBP is the concept of non-assembler-based macros and function calls. Here's what a bbound macro and send_dhcp function call within a SELECT case structure looks like in the EDTP Ethernet MINI C driver source:

```
char dhcpflags;
#define bound           0x01
#define offerrec        0x02
#define done            0x04
#define trashit         0x08
#define newdhcppkt      0x10
#define bbound  (dhcpflags & bound)
//////////////////////////////////////////////////////
case DHCP_BROADCAST:
      leasetime = 60;
      if(bbound)
      {
            DHCPSTATE = DHCP_REQUEST;
      }
      else
      {
            send_dhcp(DHCP_DISCOVER_MESSAGE);
            msecs_timer = 0;
            DHCPSTATE = DHCP_DISCOVER;
            printf("\r\nSENT DISCOVER MESSAGE..");
      }
break;
```

Since PBP doesn't support function calls with parameters, we must preload our emulated PBP function and convert the C function code to a PBP subroutine. This is illustrated by the PBP code following the else statement in the PBP if-then SELECT emulation code that follows:

```
if DHCPSTATE == DHCP_BROADCAST then
      leasetime = 60
      if bbound then
            DHCPSTATE = DHCP_REQUEST
      else
            dhcpmsgtype = DHCP_DISCOVER_MESSAGE
            gosub send_dhcp
            msecs_timer = 0
            DHCPSTATE = DHCP_DISCOVER
            hserout[13,10,"SENT DISCOVER MESSAGE.."]
      endif
goto breaker
```

Pain is not evident with every modular C-to-PBP porting operation. To handle flags such as bbound, I used an elaborate C macro scheme to clear and set software flags in the C version of the EDTP Ethernet MINI driver. Here's an example:

```
char dhcpflags;
#define bound           0x01
#define offerrec        0x02
#define done            0x04
#define trashit         0x08
#define newdhcppkt      0x10
#define bbound          (dhcpflags & bound)
#define bofferrec       (dhcpflags & offerrec)
#define bdone           (dhcpflags & done)
#define btrashit        (dhcpflags & trashit)
#define bnewdhcppkt     (dhcpflags & newdhcppkt)

#define clr_bound       dhcpflags &= ~bound
#define set_bound       dhcpflags |= bound
#define clr_offerrec    dhcpflags &= ~offerrec
#define set_offerrec    dhcpflags |= offerrec
#define clr_done        dhcpflags &= ~done
#define set_done        dhcpflags |= done
#define clr_trashit     dhcpflags &= ~trashit
#define set_trashit     dhcpflags |= trashit
#define clr_newdhcppkt  dhcpflags &= ~newdhcppkt
#define set_newdhcppkt  dhcpflags |= newdhcppkt
```

■ PHOTO 1. I love my MPLAB ICD2 hockey pucks. However, the REAL ICE is much faster when it comes to loading and debugging the PIC18F67J60 mounted on the EDTP Ethernet MINI. The REAL ICE also seems to be faster and easier to recover when communications between it and the laptop are disrupted.

Note that I simply declared a flag byte (dhcpflags) and manipulated each bit within the byte as a software flag. If you're an ATMEL AVR C programmer, you've seen this method used many times in many places. Although I lose the convenience of just saying set this or clear that, the PBP port is very clean. I utilized the native functionality of PICBASIC PRO to produce this flag manipulation port:

```
dhcpflags       var byte
bbound          var dhcpflags.0
bofferrec       var dhcpflags.1
bdone           var dhcpflags.2
btrashit        var dhcpflags.3
bnewdhcppkt     var dhcpflags.4
```

To clear the bound flag in PBP, I simply code bbound = 0. Conversely, setting the bbound bit is as easy as bbound = 1. The "b" preceding bound identifies the bbound variable is a bit variable. Just as I did in the C version of the EDTP Ethernet MINI driver, testing the flag bits is normally done with an if-then structure. For example, to test and branch on the state of the bbound flag, we code:

```
If bbound then
        do stuff here
else
        do something else here instead
endif
```

The porting techniques I've described are used throughout the new PICBASIC PRO-based EDTP Ethernet MINI driver. There's more ported EDTP Ethernet MINI code than I can show you and talk about here. So, I've provided a full listing of both the C and PICBASIC PRO versions of the EDTP Ethernet MINI driver on the *Nuts & Volts* website (**www.nutsvolts.com**). You can also get the code sets from the EDTP Electronics site. I've tried to keep the C and PICBASIC PRO source code versions in sync so you can follow the port from C to PICBASIC PRO line-by-line.

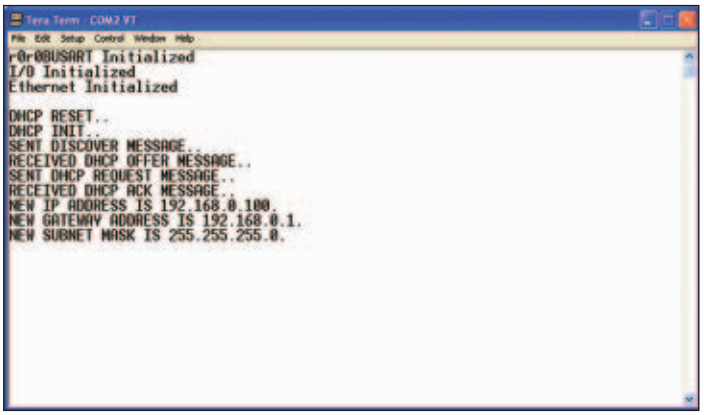
VERIFYING THE PORT

Just sitting behind my ThinkPad plinking out PBP code is one thing. Sitting behind three ThinkPads verifying my plinking is another. Here's the 3-D setup with "our" ThinkPad residing in your virtual lap. The EDTP Ethernet MINI hardware is connected to our ThinkPad via Microchip's REAL ICE, which is attached via USB. Our ThinkPad is running the MPLAB IDE, which is supporting the PICBASIC PRO compiler and the REAL ICE debugger/programmer. All of the porting, loading, and debugging of the EDTP Ethernet MINI hardware is done from our ThinkPad. For those of you that are not familiar with the Microchip REAL ICE, I've put one under the camera in Photo 1.

The ThinkPad to the left is attached via CAT5 cable to a LinkSys EtherFast Cable/DSL router, which is acting as the DHCP server for our little EDTP Ethernet MINI/ThinkPad network. In addition to being the second host on the EDTP Ethernet MINI network, the left-hand ThinkPad is also running Tera Term Pro, an RS-232 terminal emulator application, at 57600 bps. Since these new-fangled laptops dropped their native RS-232 ports in favor of USB interfaces, I'm forced to connect the left-hand ThinkPad's emulated COM2 to the EDTP Ethernet MINI's serial port via a USB-to-serial dongle. The third ThinkPad to the right is dedicated to running Network General's Sniffer Portable LAN Suite, which we will use to capture all of the DHCP activity flying around. Photo 2 shows them all chugging along.

If you've got your copy of the PBP source code port handy, you'll see that I converted and coded a DHCP send routine, a DHCP receive routine, and a DHCP send_bound_message routine. Each routine that is important to us has a "talker" routine within it that sends a human readable serial message to the left-hand ThinkPad running

■ PHOTO 2. The array of ThinkPad laptops used for development and debugging. On the left, the DHCP server and comm front end; in the center, the development system for the MINI, connected through REAL ICE; and on the right, the network sniffer.



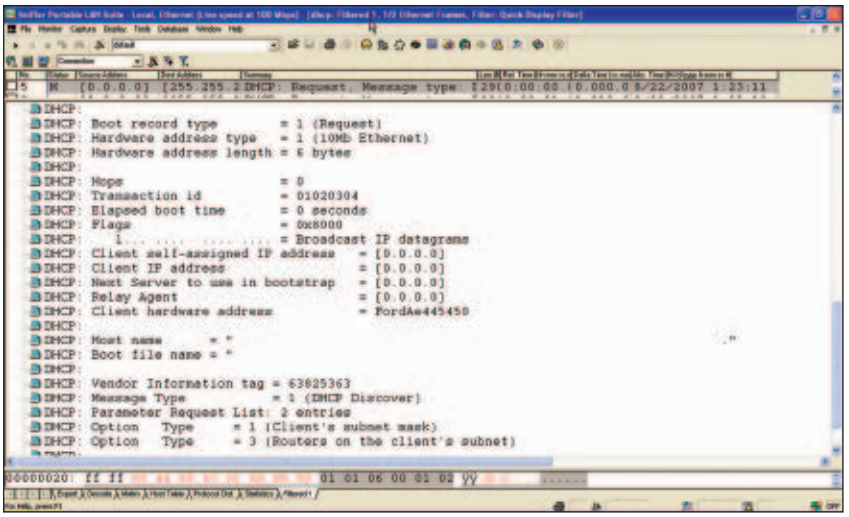
■ SCREENSHOT 1. This all goes back to my love of using an embedded device's RS-232 port as a debugging tool. During the debugging phase, if I didn't get the message I wanted to see here, or the messages were looping, I would then turn my attention to reading dumps and registers produced by the Microchip REAL ICE to find a fix.

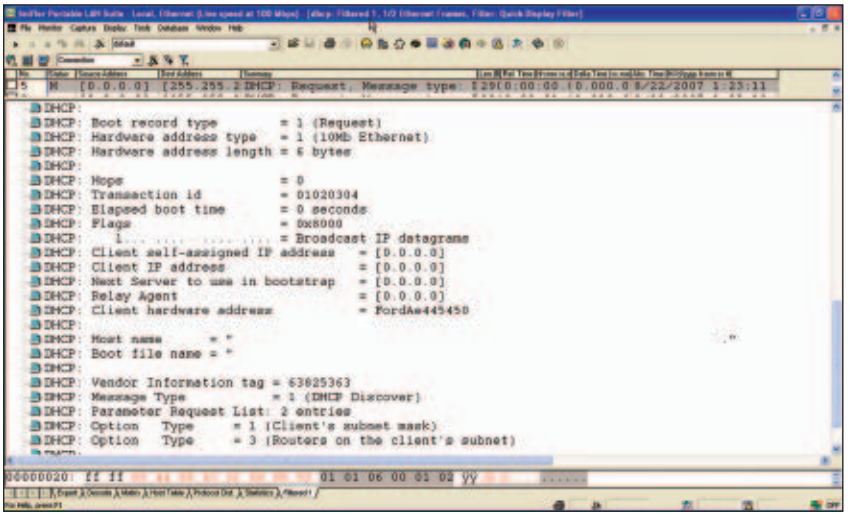
Tera Term Pro. If everything works as designed, that same ThinkPad that is receiving the serial messages from the EDTP Ethernet MINI's RS-232 port is also tasked with running the Microchip MCHPDetect program. The MCHPDetect program is looking for UDP broadcast messages on the network aimed at UDP port 30303. The send_bound_message routine in our PBP EDTP Ethernet MINI driver heaves the DHCP-parameters-laden UDP datagram at UDP port 30303. The left-hand ThinkPad, being an active participant in the network, is listening for UDP traffic addressed to UDP port 30303 by way of the MCHPDetect application it is running.

When the bits all line up, here's what should happen. Since we have not specified that the DHCP engine be disabled at compile time, the dhcp_state_engine subroutine will be called. The dhcp_state_engine DHCP_ENTRY and DHCP_INIT if-then constructs will execute and we will see the talker statements DHCP RESET and DHCP INIT appear in the Tera Term Pro terminal emulator window. I've captured the Tera Term Pro output in Screenshot 1.

Approximately two seconds later, the PBP EDTP Ethernet MINI driver will issue a DHCP Discover message via the send_dhcp subroutine. The talker statement SENT DISCOVER MESSAGE will appear on the ThinkPad running Tera Term Pro when the Discover message is sent. I just happened to have the right-hand ThinkPad and Sniffer Portable LAN Suite online and I captured the EDTP Ethernet MINI's outgoing DHCP Discover message in Screenshot 2.

■ SCREENSHOT 2. Since you can't really see the entire Sniff, this shot is aimed at providing a verification of the EDTP Ethernet MINI sending a correctly assembled DHCP Discover message. Note that I have asked for the network's subnet mask and the IP addresses of any routers on the network. The fabricated non-IEEE-issued MAC address of 00EDTP results in the Sniffer incorrectly identifying us as IEEE-legal FordAe45450.



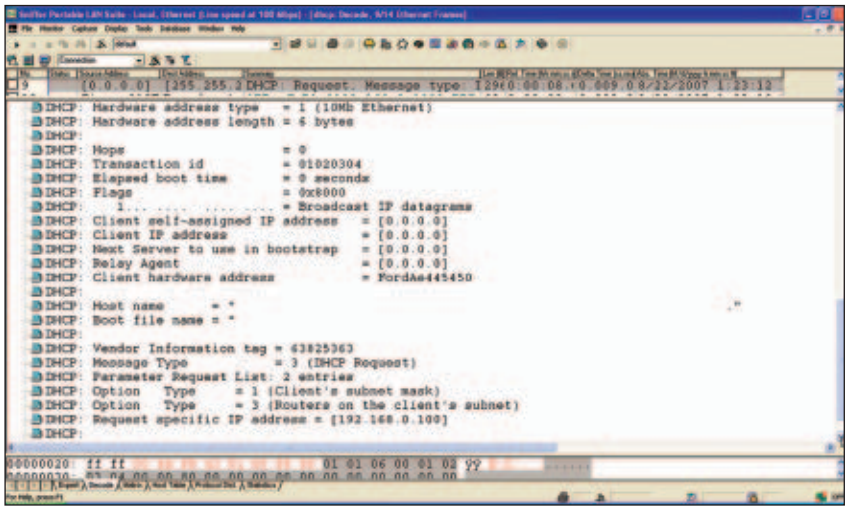


With a certified DHCP Discover on the way to the Linksys router, the PBP EDTP Ethernet MINI driver will then sit back and wait for a response from the Linksys router, which is configured as the EDTP Ethernet MINI LAN's DHCP server. The ThinkPad running Tera Term Pro has a hard-coded IP address below 192.168.0.100, which means our EDTP Ethernet MINI hardware should request and receive the first DHCP pool IP address of 192.168.0.100. The ThinkPad running the Sniffer Portable LAN Suite is not an active participant in the network it is monitoring and will not request an IP address from the Linksys router.

The Linksys router sees our DHCP Discover message and returns a DHCP Offer message, which kicks off the talker message RECEIVED DHCP OFFER MESSAGE on our ThinkPad that is running the Tera Term Pro terminal emulator application. The Sniffer Portable LAN Suite application is still monitoring the network and captures the Linksys-generated DHCP Offer

■ SCREENSHOT 3. I squeezed in all of the important stuff into this shot. Not only did we get all of the optional parameters we asked for, we also received an available IP address and lease time value that we may choose to use or reject.

■ SCREENSHOT 4. We could opt to reject the offer. However, there are no other routers on the network and the EDTP Ethernet MINI would just sit there asking for and rejecting offers from the Linksys router forever. So, in this shot we are asking to lease the IP address 192.168.0.100.



Sniff you see in Screenshot 3.

Taking a look at Screenshot 3, we find everything we need to put the EDTP Ethernet MINI on the network. Note the Request IP address lease time value. Yet another pothole for PICBASIC PRO; 172800 decimal seconds equates to $2A300 PICBASIC PRO hexadecimal seconds. The lease time value is beyond the 16-bit arithmetic limit of PICBASIC PRO. Although there are 32-bit tricks PICBASIC PRO can perform, we'll fill this pothole with caveman code. The lease time variable is 32 bits in length. To handle it with PBP, we need to arrange the 32 bits into PBP-chewable bytes:

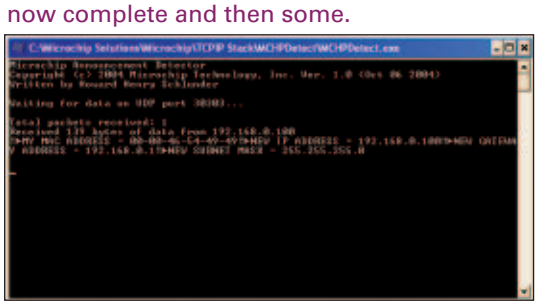
```
templeasetimec[0]        ; MSB
templeasetimec[1]
templeasetimec[2]
templeasetimec[3]        ; LSB
```

The lease time byte arrangement allows us to use caveman code to perform the 32-bit arithmetic as shown in the code that follows:

```
if templeasetimec[2] >= $07  then
for i16 = 0 to 1799
        templeasetimec[3]=templeasetimec[3]-1
        if templeasetimec[3] == $FF then
                templeasetimec[2] =
                  templeasetimec[2] - 1
        endif
        if templeasetimec[2] == $FF then
                templeasetimec[1] = templeasetimec[1] - 1
        endif
        if templeasetimec[1] == $FF then
                templeasetimec[0] = templeasetimec[0] - 1
        endif
next i16
```

The lease time code I have presented is used to subtract 1800 seconds from the lease time value that is offered to us by the Linksys router within the DHCP Offer message. We can use the same caveman algorithm to determine when the lease expires:

■ SCREENSHOT 6. This is simply gravy over the meat and potatoes. The verification process is now complete and then some.



```
if DHCPSTATE == DHCP_BOUND then
    if bleaseflag then
        bleaseflag = 0
        templeasetimec[3] = templeasetimec[3] - 1
        if templeasetimec[3] == $FF then
            templeasetimec[2] = templeasetimec[2] - 1
        endif
        if templeasetimec[2] == $FF then
            templeasetimec[1] = templeasetimec[1] - 1
        endif
        if templeasetimec[1] == $FF then
            templeasetimec[0] = templeasetimec[0] - 1
        endif
        if templeasetimec[0] == 0 && _
        templeasetimec[1] == 0 && _
        templeasetimec[2] == 0 && _
        templeasetimec[3] == 0 then
            hserout [13,10,"DHCP LEASE TIME EXPIRED.."]
            DHCPSTATE = DHCP_INIT
        endif
    endif
endif
```

I added a bleaseflag bit variable to the existing dhcpflags byte variable. If you look at the timer interrupt routine in the PBP driver source code, you'll see that I set the bleaseflag

■ SCREENSHOT 5. This is the DHCP message we've been working to receive. Everything the EDTP Ethernet MINI needs to get onto the network is here.

every second. When the dhcp_state_engine subroutine is called, the bleaseflag value is checked and if the bleaseflag is set and the EDTP Ethernet MINI is bound to the Linksys router, the 32-bit lease time value is decremented. If the lease time value rolls into zero, the dhcp_state_engine code kicks off another DHCP lease request to the Linksys router.

Before we can use any of that nifty 32-bit caveman arithmetic, we must accept the gracious offer that the Linksys router has given to us. We do that by blasting out a DHCP Request message, which is seen in Sniffer format in Screenshot 4.

Up to this point, our ported PICBASIC PRO EDTP Ethernet MINI driver code is working perfectly. There's only one more step to gaining access to the network: receiving the acknowledgment message to our lease request. The positive acknowledgment talker message in Screenshot 1 backs up the DHCP Ack Sniffer capture you see in Screenshot 5. All that's left to do is parse the incoming DHCP Ack message and place the IP addresses, subnet masks, and lease time values into their proper memory slots.

Once the EDTP Ethernet MINI received its new IP and gateway addresses, the send_bound_datagram subroutine pushed a UDP datagram out onto the network. The MCHP Detect application captured the data you see in Screenshot 6.

ANOTHER BRICK IN THE WALL

You have joined an elite club. You are now part of the initial PICBASIC PRO EDTP Ethernet MINI driver rollout. To my knowledge, at this time there are no other free PICBASIC PRO ports of PIC18F67J60 network drivers available to the public.

The only brick that is yet to be placed in our PICBASIC PRO wall of networking fame is TCP. I think you all have enough knowledge to get that done without talking about it in an additional installment of Design Cycle. You have the C template in the PIC BASIC PRO port download package. And, you know all of my tricks. I'm sure you also have some tricks of your own. So, go forth and network, you Basic lovers. Make Peter and his potties proud! See you next time. **NV**

SOURCES

- *microEngineering Labs* (**www.melabs.com**): PICBASIC PRO
- *EDTP Electronics, Inc.* (**www.edtp.com**): EDTP Ethernet MINI
- *Microchip* (**www.microchip.com**): PIC18F67J60; MPLAB; REAL ICE
- *Network General* (**www.networkgeneral.com**): Sniffer Portable LAN Suite
- *HI-TECH Software* (**www.htsoft.com**): The original EDTP Ethernet MINI driver C application was coded with HI-TECH PICC-18.

CONTACT THE AUTHOR

- *Fred Eady can be reached via email at fred@edtp.com.*

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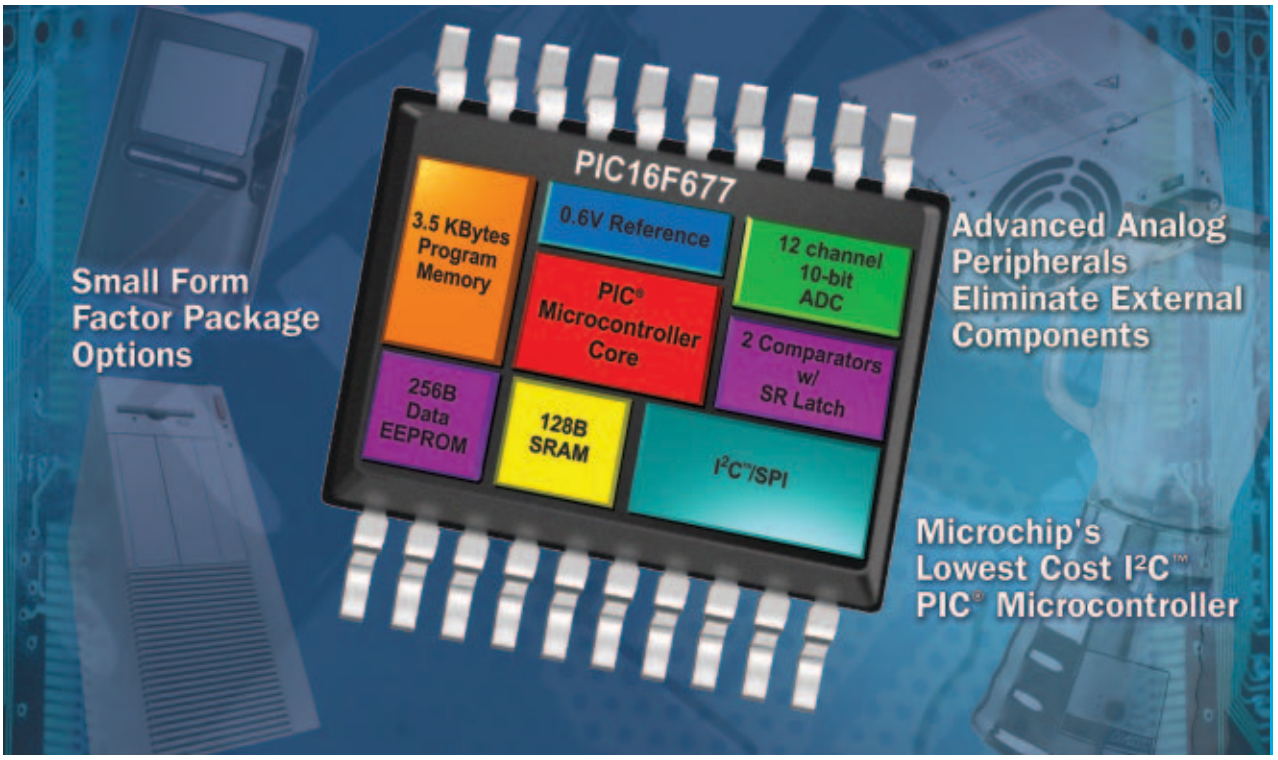

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NEW!	PIC16F631	1024	64	128	0	1/1		PDIP, SSOP, SOIC, 4mm x 4mm QFN
NEW!	PIC16F677	2048	128	256	12	1/1	SPI/I²C™	PDIP, SSOP, SOIC, 4mm x 4mm QFN
	PIC16F685	4096	256	256	12	2/1	ECCP+	PDIP, SSOP, SOIC, 4mm x 4mm QFN
	PIC16F687	2048	128	256	12	1/1	EUSART, SPI/I²C™	PDIP, SSOP, SOIC, 4mm x 4mm QFN
	PIC16F689	4096	256	256	12	1/1	EUSART, SPI/I²C™	PDIP, SSOP, SOIC, 4mm x 4mm QFN
	PIC16F690	4096	256	256	12	2/1	ECCP+, EUSART, SPI/I²C™	PDIP, SSOP, SOIC, 4mm x 4mm QFN
	PIC16F785	2048	128	256	12	2/1	Op Amps, CCP, Hardware PWM	PDIP, SSOP, SOIC, 4mm x 4mm QFN

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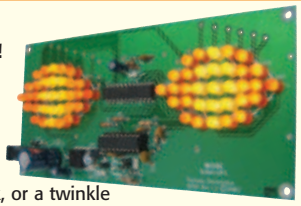
RAMSEY
Spooktacular Halloween Treats!

Blinky-Eyes Animated Display



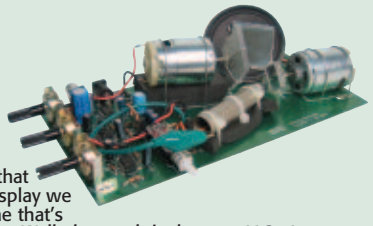
- ✔ **Animated display of 66 super bright LED's!**
- ✔ **Microcontroller controlled!**
- ✔ **Changes brightness automatically!**
- ✔ **Animated with constant motion!**

The ultimate animated LED kit that will dazzle you and delight your friends! Uses a microcontroller to randomly select from many different animations such as a long pause before a wink, or a twinkle of the eye to startle passers-by!

Four modes to satisfy any enthusiast's desires: 1. Off for long random periods, then blinks or winks. Designed to scare! 2. On for long periods before performing an animation, perfect for costumes and displays! 3. Animates all the time for constant motion, perfect display attention-getter. 4. Random fire! When placed in a pumpkin will light it up like you wouldn't believe! As if this weren't enough, the BE66 can also control a small hobby motor to shake bushes at random intervals or signal an external player to make a scary sound! Also has a CDS cell to sense light. In one mode, the display will dim as it gets dark for battery operation, and in the other it will turn off when it's too bright, so it plays only in the dark!

BE66 **Blinky-Eyes Animated Display Kit** **$59.95**

Laser Light Show



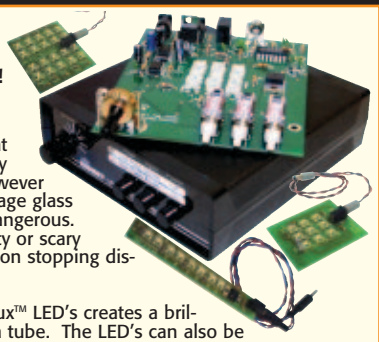
- ✔ **Audio input modulates pattern!**
- ✔ **Adjustable pattern & size!**
- ✔ **Projects neat motorized patterns!**
- ✔ **Uses safe plastic mirrors!**

You've probably seen a laser show at concerts or on TV. They're pretty impressive to say the least! Knowing that you can't afford a professional laser display we challenged our engineers to design one that's neat and easy to build, yet inexpensive. Well, the result is the new LLS1 Laser Light Show! This thing is sweet and perfect for your haunted house or halloween parties! It utilizes two small motors and a small standard laser pointer as the basics. Then, we gave it variable pattern and speed controls to customize the pattern!

Not enough, you say? How about a line level audio input to modulate the pattern with your CD's, music, or spooky sound effects? You bet! Everything is included, even the small laser pointer. Runs on 6-12 VDC or our standard 12VDC AC Adapter (not included).

LLS1	**Laser Light Show Kit**	**$44.95**
PS21	**12VAC Output 110VAC Power Supply**	**$19.95**

LED Strobe Light



- ✔ **Everlasting LED's won't burn out!**
- ✔ **Variable flash rate & audio trigger!**
- ✔ **Bass & treble trigger modes!**
- ✔ **Safe low voltage operation!**

You have all seen those strobe lights at the special gift shops in the mall. They have been around for a long time, however they all feature one thing... a high voltage glass Xenon tube, that is both fragile and dangerous. Now you can illuminate your next party or scary Halloween setting with the same motion stopping display without worry!

A plug-in 3x3 array of super bright Telux™ LED's creates a brilliant sharp flash just like a Xenon flash tube. The LED's can also be mounted directly on the main PC Board if desired. In the standard flash mode, a variable rate control varies the flash frequency from approx 1 to 220 flashes per second. In the audio sync mode, the flash is triggered by any audio input you provide into the standard RCA audio input connector. Built-in low and high pass filters allow you to select either bass or treble music triggering! Just picture the strobe reacting to those Halloween sound effects CD's! An external trigger in/out connector lets you connect multiple units together for simultaneous flash.

Optional plug-in display boards with 8 or 20 LED's are available for even more strobing power! These are perfect to put inside a pumpkin! Runs on 12-15 VDC, and unlike the high voltage Xenon strobes of the past, the LEDS1 is safe for the kids to build! Includes a matching custom case and knob set to give your strobe light a great finished look. The plug-in display boards may be mounted on top of the case, or remotely located

LEDS1C	**High Power LED Strobe Light Kit With Case**	**$44.95**
LEDS8	**Display Board, Inline Array of 8 LED's**	**$17.95**
LEDS20	**Display Board, 5x4 Array of 20 LED's**	**$29.95**
AC125	**110VAC Power Supply**	**$9.95**

Automatic Animated Ghost

- ✔ **Automatically greets your visitors!**
- ✔ **Responds to sudden noises!**
- ✔ **Built-in microphone!**
- ✔ **Adjustable sensitivity**

Who says there aren't such things as ghosts? Once your friends come upon this one they'll think differently! The unique circuit board design includes two ominous blinking eyes that change with various conditions, including sudden changes in ambient noise. A highly sensitive built-in microphone picks up anything from noises to talking and makes the ghost dance with its built-in motor, make eerie sounds with the built-in speaker, and randomly blink. A white cloth and a hanger are included as shown to make it look like the real thing. Runs on 2 AAA batteries (Not included).

MK166 **Automatic Animated Ghost Kit** **$23.95**

Halloween Pumpkin

- ✔ **25 bright LED's!**
- ✔ **Random flash simulates flickering candle!**
- ✔ **Super bright LED illuminates entire pumpkin!**
- ✔ **Simple & safe 9V battery operation**

The perfect "starter" kit with a terrific Halloween theme! You won't be scraping the seeds and guts out of this pumpkin! Six transistor circuit provides a neat random flash pattern that looks just like a flickering candle. Then a super bright LED illuminates the entire pumpkin with a spooky glow!

The pumpkin face is the actual PC board, and assembly is easy through-hole soldering of all components and LED's. Your pumpkin is powered by a standard 9V battery (not included) which snaps to the back of the pumpkin. An on/off switch is also included. Create a new kind of pumpkin this year, and learn about LED's and electronics at the same time!

MK145 **Electronic Halloween Pumpkin Kit** **$9.95**

Portable EL Electroluminescence

- ✔ **3.3 feet long!**
- ✔ **Low power consumption!**
- ✔ **Highly visible brilliant colors**

Electroluminescence illuminated flexible wire sets can be used for a lot of things but when they're battery powered they're perfect for Halloween and Trick or Treat safety concerns! Each thin, flexible EL wire set is 3.3' long and runs on two standard AA batteries (not included). Current consumption is less than 100mA for long life.

Mode settings include steady glow and slow or fast flash! Make it part of a brilliantly lit, custom designed costume or simply add it for illuminated safety while Trick or Treating in the dark.

NWRR15	**EL Illumination Wire Set, Red**	**$19.95**
NWRG15	**EL Illumination Wire Set, Green**	**$19.95**
NWRB15	**EL Illumination Wire Set, Blue**	**$19.95**

LED Red Blinky

- ✔ **Great pumpkin eyes!**
- ✔ **Decorate your costume!**
- ✔ **Easy assembly**

A Halloween favorite! Alternately flashes two jumbo red LEDs that can be used as pumpkin eyes, costume eyes or other attention grabbers. This is the kit you've seen on name badges, buttons, hats, and toys. But, there's more to it than that. Add a couple of relays and Christmas light strings and you've got yourself a super light chaser just like the theater marquee. Runs on 3-5 VDC, typically a 9V battery (not included).

BL1 **LED Blinky Kit** **$7.95**

LED SMT Blinky

- ✔ **Submini SMT eyes!**
- ✔ **High intensity LEDs**
- ✔ **Learn SMT**
- ✔ **Extra parts!**

The subminiature high tech version of our classic BL1 blinky kit! This one is really neat and is designed using surface mount technology (SMT). The ultra bright SMT LEDs alternately flash crating a brilliant display. Runs on two LR55 button cells that are included to make it small enough to fit any application. Great attention grabber for any costume. We even include extra SMT parts and two standard LEDs in case you lose the SMT parts!

BL2 **LED SMT Blinky Kit** **$17.95**

Did You Know...

- ✔ *It's impossible to give you full specs on these products in a 1" space!*
- ✔ *A lot of our kits are also available "factory assembled and tested", if you don't want to build it!*
- ✔ *We have over 350 products currently available, and all those don't fit here!*

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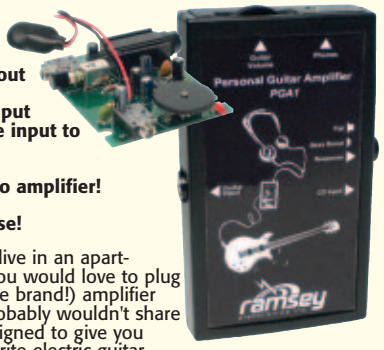


- ✔ **Practice your guitar or bass without disturbing others!**
- ✔ **Standard ¼" guitar audio plug input**
- ✔ **CD/MP3 player audio headphone input to practice to your favorite music!**
- ✔ **Switchable bass boost!**
- ✔ **Great as a DI to your home stereo amplifier!**
- ✔ **Uses standard 9V battery**
- ✔ **Includes guitar strap/belt clip case!**

So you're a guitar musician, and you live in an apartment...what else needs to be said! You would love to plug into your 100 watt HiWatt (my favorite brand!) amplifier and let it crank, but the neighbors probably wouldn't share your enthusiasm! The PGA1 was designed to give you hours of enjoyment playing your favorite electric guitar while isolating your family, friends, and neighbors from your music and your passion. *(I still use the original engineering prototype with my SG with P90's!)*

Whether you use an acoustic electric, electric, or bass guitar, the PGA1 gives you an adjustable volume output to your favorite headphones. Unlike a lot of practice amps, the PGA1 has a special bass boost to enhance bass guitar use. One practice amp for all your guitars! If you want to practice to your favorite music, the PGA1 has a standard style audio input to play to your favorite music! Just plug in your Walkman style CD player, MP3 player, or even the headphone output on your mixer board and you'll hear both your music source and your guitar in your headphones!

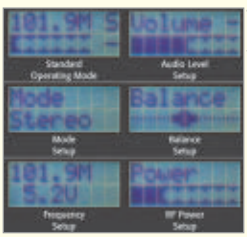
The PGA1 uses a powerful LM386 power amplifier to provide one watt of power to your headphones, or even a small speaker! It gets even better...use the PGA1 as a cheap and easy direct inserter box to match your guitar into an aux input of a stereo receiver amplifier or PA amplifier! It sounds GREAT! A standard ¼" audio input connector is used for your guitar input, matching your standard guitar cables. A top mounted on/off/volume control adjusts the headphone output level through the full range. The small belt clip pocket size device runs on a standard 9V battery (not included). A LED indicates power-on and relative battery condition. The attractive compact case measures 4.5"H x 2.7"W x 1.1"D.

PGA1	**Personal Practice Guitar Amplifier Kit**	**$64.95**
PGA1WT	**Personal Practice Guitar Amp, Factory Asmb & Tested**	**$99.95**

Digital FM Stereo Transmitters

- ✔ **Rock stable PLL synthesized**
- ✔ **Front panel digital control and display of all parameters!**
- ✔ **Professional metal case**
- ✔ **Super audio quality!**
- ✔ **25mW and 1W models!**

For nearly a decade we've been the leader in hobbyist FM radio transmitters. Now for 2005 we introduce our brand new FM30 series of FM Stereo Transmitters! We told our engineers we wanted a new technology transmitter that would provide FM100 series quality without the advanced mixer features. They took it as a challenge and designed not one, but TWO transmitters!



The FM30 is designed using through-hole technology and components and is available only as a do-it-yourself kit, with a 25mW output very similar to our FM25 series. Then the engineers redesigned their brand-new design using surface mount technology (SMT) for a very special factory assembled and tested FM35WT version, with 1W output for our export market! Both are designed around an RF tight vinyl clad metal enclosure for noise free and interference free operation. All settings are done through the front panel digital control and LCD display! All settings are stored in non-volatile memory for future use.

Both the FM30 and FM35WT operate on 13.8 to 16VDC and include a 15VDC plug-in power supply. The stylish metal case measures 5.55"W x 6.45"D x 1.5"H and is available in either white or black. *(Note: The end user is responsible for complying with all FCC rules & regulations within the US, or any regulations of their respective governing body. FM35BWT is for export use only and can only be shipped to locations outside the continental US or valid APO/FPO addresses or valid customs brokers for verified end delivery outside the continental US).*

FM30B	**Digital FM Stereo Transmitter Kit, 0-25mW, Black**	**$199.95**
FM35BWT	**Digital FM Stereo Transmitter, Assembled, 1W, Black**	**$299.95**

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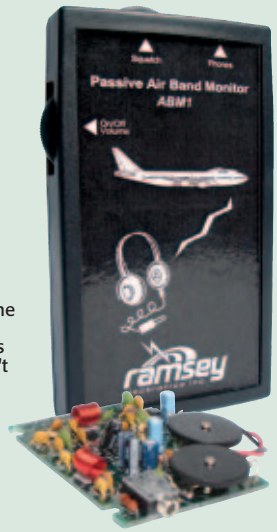
Passive Air Band Aircraft Monitor



- ✔ **Monitors the entire aircraft band without tuning!**
- ✔ **Passive design, can be used on aircraft, no local oscillator, generates and creates no interference!**
- ✔ **Great for air shows**
- ✔ **Patented circuit and design!**

Written Up In Communications Magazines Worldwide!

For decades we have been known for our novel and creative product designs. Well, check this one out! An aircraft receiver that receives all nearby traffic without any tuning. It gets better... there is no local oscillator so it doesn't produce, and can't produce, any interference associated with all other receivers with an LO. That means you can use it onboard aircraft as a passive device! And what will you hear? The closest and strongest traffic, mainly, the plane you're sitting in! How unique is this? We have a patent on it, and that says it all!

This broadband radio monitors transmissions over the entire aircraft band of 118-136 MHz. The way it works is simple. Strongest man wins! The strongest signal within the pass band of the radio will be heard. And unlike the FM capture effect, multiple aircraft signals will be heard simultaneously with the strongest one the loudest! And that means the aircraft closest to you, and the towers closest to you! All without any tuning or looking up frequencies! So, where would this come in handy?

1. ***At an air show! Just imagine listening to all the traffic as it happens***
2. ***Onboard aircraft to listen to that aircraft and associated control towers***
3. ***Private pilots to monitor ATIS and other field traffic during preflight activities (saves Hobbs time!)***
4. ***Commercial pilots to monitor ATIS and other field traffic as needed at their convenience***
5. ***General aircraft monitoring enthusiasts***

Wait, you can't use a radio receiver onboard aircraft because they contain a local oscillator that could generate interfering signals! We have you covered on that one. The ABM1 has no local oscillator, it doesn't, can't, and won't generate any RF whatsoever! That's why our patent abstract is titled "Aircraft band radio receiver which does not radiate interfering signals". It doesn't get any plainer than that!

SPECIFICATIONS	
Frequency Range:	118 MHz to 136 MHz
Receiver Type:	Patented Passive Detector
IF Frequencies:	None!
Receiver Sensitivity:	Less than 2 uV for detectable audio
Audio Output:	700mW, 8-24 ohms
Headphone Jack:	3.5mm stereo phone, stereo earbuds included
External Antenna:	Headphone cord coupled
Power Requirement:	9VDC battery
Dimensions:	2.25" x 2.8" PC Board 2.5" x 4.6" x .9" Case
Weight:	4 oz. with battery

Even with its compact design, we designed the ABM1 for easy construction by the electronic hobbyist. Thru-hole parts are used for all customer assembly. Several SMT components are part of the circuit, and they are pre-installed at the factory! In addition, a factory assembled and tested SMT version with additional shielding for adjacent channel overloading is also available for the aircraft professional that just wants to get listening quickly. Stereo earbuds are even included! If you're a private pilot, commercial pilot, airport worker, aircraft enthusiast, attend air shows, or spend a lot of time in airports or onboard aircraft, the ABM1 is for you!

ABM1	**Passive Air Band Monitor Kit**	**$89.95**
ABM1WT	**Passive Air Band Monitor, Factory Assembled & Tested**	**$159.95**

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Q&A

WHAT'S UP:

Join us as we delve into the basics of electronics as applied to every day problems, like:

- ✓ **Battery Saver**
- ✓ **Surround Sound**
- ✓ **Mailbag**

■ WITH RUSSELL KINCAID

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist. Feel free to participate with your questions, comments, or suggestions.

Send all questions and comments to:
Q&A@nutsvolts.com

DETECTION OF STOPPED OBJECT IN A ZONE

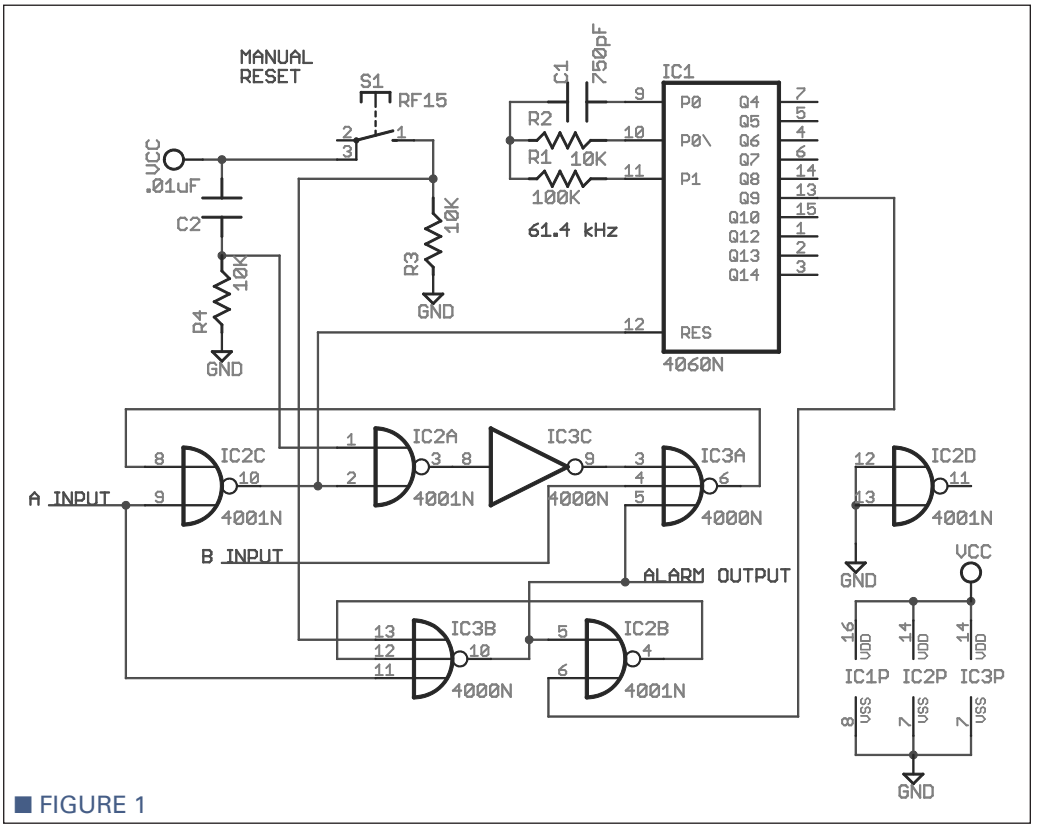
Q I have a farm. I would like a circuit that will detect cars going into a zone on the road. I want to know if a car stops within the zone and does not pass through within a given time (around 30 seconds) from one direction only. For the detectors, I am using two battery-operated infrared sensors that send the detected trigger signal via RF back to a radio receiver. The output of the receiver would then go to the proposed circuit. This circuit could also be used in an industrial conveyor detection system as well, since the objective is the detection of an object going into a zone from only one direction and stopping. I would like to use all solid-state components.

— Bill Mack
Minneapolis, MN

A You have two sensors: A and B. If A senses a vehicle but B does not, we assume the vehicle stopped between A and B. If both A and B sense a vehicle, we assume it passed through and we don't care about that. If B senses the vehicle first, it is going in the opposite direction and we don't care about that either. The circuit will produce an alarm output if the time between A and B exceeds 30 seconds.

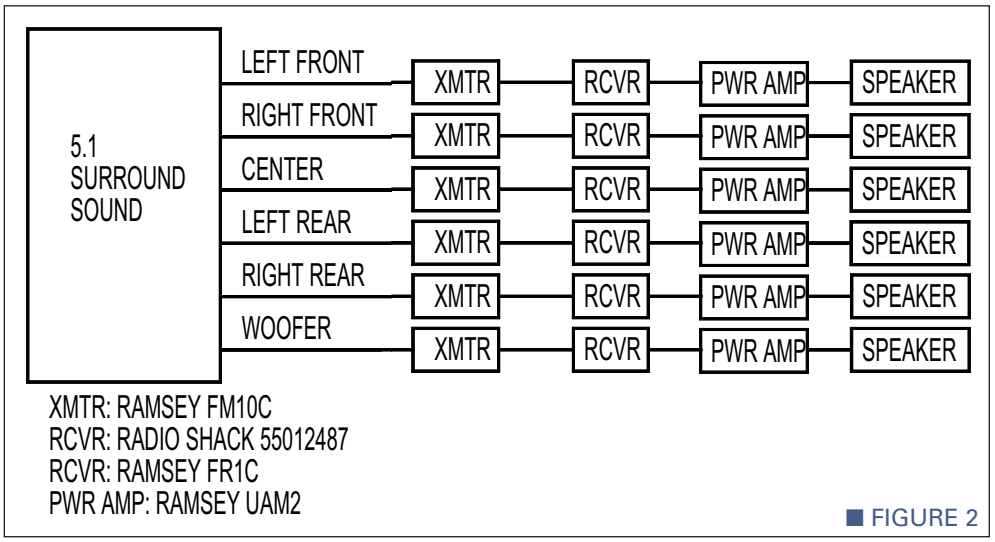
The circuit in Figure 1 works like this: IC1 is a 30 second timer; Q9 output goes high after 30 seconds. A set-reset flip-flop is formed by IC2C, IC2A, IC3C, and IC3A. I call this the start-stop flip-flop. A second set-reset flip-flop is formed by IC3B and IC2B. I call that one the alarm flip-flop.

When power is turned on, you want the start-stop flip-flop to be reset, ready to accept a positive pulse from the A input. That is the function of C2 and R4. The alarm flip-flop could power up in either state; you might have to press the manual reset to turn the alarm off. When a positive pulse occurs at the A input, the start-stop flip-flop is set and the counter starts. At the same time, the alarm flip-flop is reset if it was not already. If a positive pulse



■ FIGURE 1

occurs at the B input before the counter times out, the start-stop flip-flop is reset and the counter stops until another pulse occurs at the A input. If the B pulse does not happen and the timer times out, the alarm flip-flop is set, the timer stops, and stays in that condition until manually reset or another A input pulse occurs. VCC can be between five and 15 volts DC.



■ FIGURE 2

SURROUND SOUND

Q I am looking for a schematic for a transmitter and receiver that can be integrated into my home entertainment system. I have 5.1 surround and would like to find some way of sending the separate signals for each channel without the use of speaker wire. The transmitter can run off 110 VAC and the receivers can be battery operated. Any ideas would be appreciated.

— Robert Burleigh

A My solution is straightforward but has lots of parts (see Figure 2). You can build the units from kits or buy ready-made units. The FM transmitter will be L-C tuned — not crystal controlled — unless you go for an expensive setup. The receiver also has to be L-C tuned, not frequency synthesized because the transmitter will drift in frequency. The L-C tuned receiver will have AFC (automatic frequency control) and be able to track the drifting transmitter.

MAILBAG

Dear Russell,

Here is an alternative for your R/C Eliminator schematic, Figure 6 on page 27 of the August '07 *Nuts & Volts*. This should eliminate both the high speed pulses and the gap in pulses you mentioned with the two switch types. I have reproduced only the right half of that figure and simplified the capacitor arrangement in Figure 3.

— Edwin Hampton

Response: Thanks for the feedback, that is one to remember!

— Russell

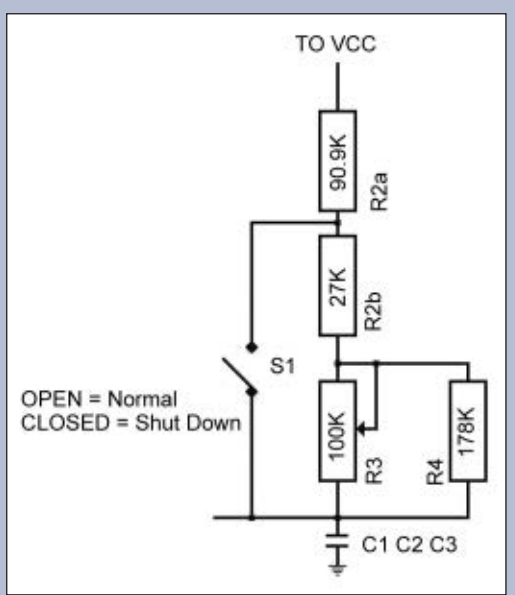
Dear Russell,

A source that I use for up to 60 watts at 1.5 MHz is the LM12. National made this power op-amp about 20 years ago and there are still tens of thousands in supply, so I think they qualify as hobby material. I seem to remember the spec as 60 Vpp max, 10 amp max and unity gain at 3 MHz. I forget if the LM12 is unity gain stabilized, but I usually feed them back at X10 gain and set a signal divider on the input to give the desired output swing. They come in a five pin TO-3 case and there used to be sockets available for them. I usually use a Texas size heatsink designed for a three pin TO-3. I think Jameco (**www.jameco.com**) sells the insulating mica for them; I use this as a template to drill the other three holes in the heatsink. Two of the pins match the normal TO-3 pattern.

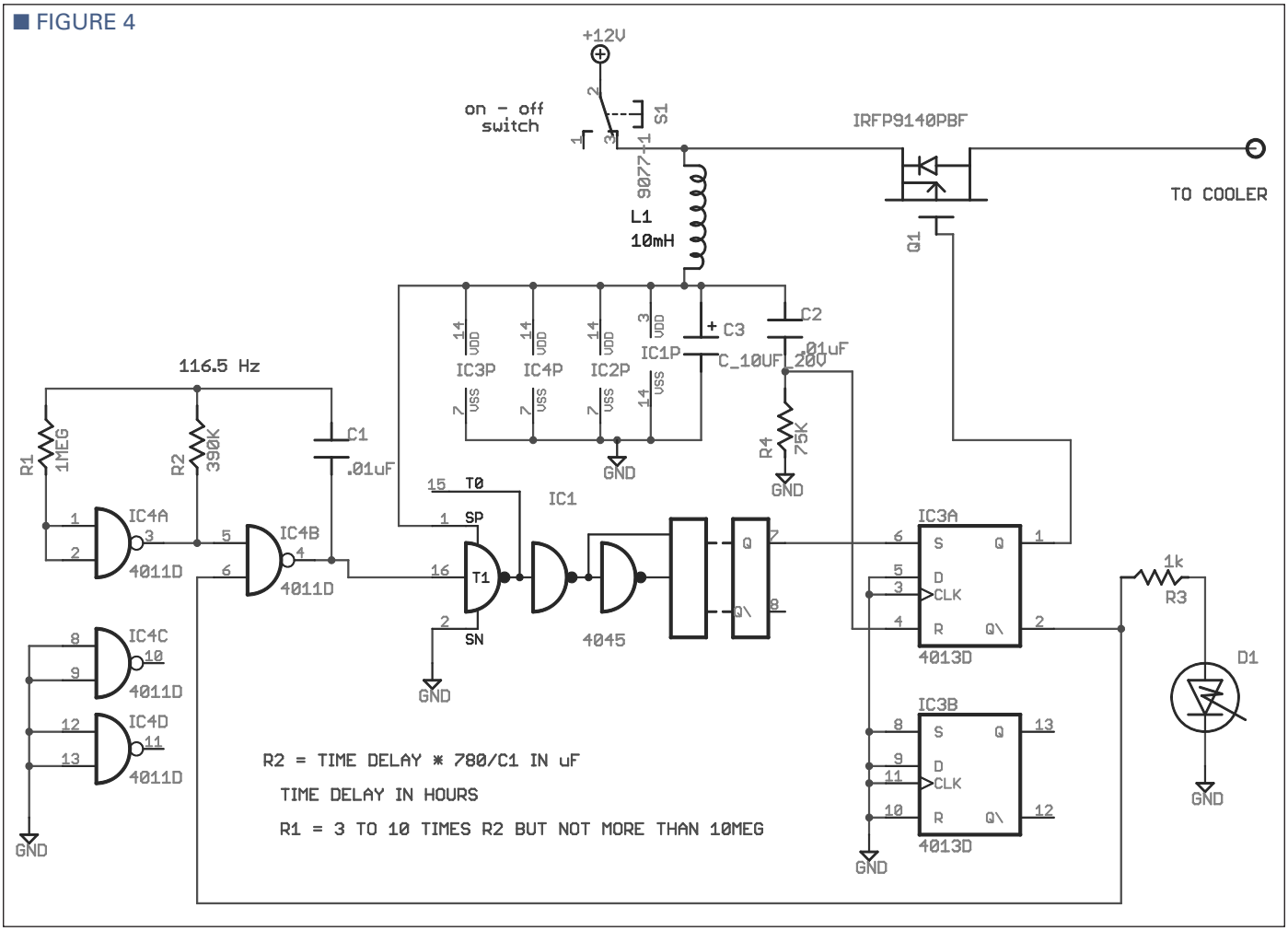
— Joe

Response: I looked up the LM12 and found that Digi-Key has it in stock for $42 each. The version available now has four pins (case is V-) and has a small signal band width of 700 kHz. It will output 10 amps and has a power bandwidth of 60 kHz. The older five pin device was no doubt compensated for a gain of 10. Anyone planning to use it for high frequency should insure that they are getting the five pin device.

— Russell



■ FIGURE 4



The RadioShack receiver is inexpensive but you might want to use a Ramsey kit (**www.ramseyelectronics.com**) for a better looking integration. The 20 watt class D audio amp from Ramsey should be plenty of power; you will have 120 watts total with all six working. I built a class D amp once; the intermodulation distortion was horrible, but I guess the ear is not very discerning because I have never heard anyone complain about it.

BATTERY SAVER

Q I'd like to build a 12V battery saver. I have a 12V cooler in my SUV but if I use it too long, my battery

Mailbag continued ...

Dear Russell,

In the July '07 issue, you stated that the program was written in PICBASIC. Whose version of PICBASIC are you referring to? Is the program available for download?

— Gunther Hartung

*Response: PICBASIC and PICBASIC PRO compilers are available from microEngineering Labs, Inc. (**www.melabs.com**). You will also want Microcode Studio or the Microcode Studio Plus integrated development environment, also available from microEngineering Labs. Microcode Studio is free but only supports 16F628.*

— Russell

Dear Russell,

I believe there are several errors on pages 30 and 32 of the July issue. Figure 7 shows D1 as 1N4149 and the text calls it 1N4148. Figure 11 shows D2 and D3 in the wrong direction; I believe it requires a positive voltage to initiate the threshold. If so, the diodes should be reversed. If not, would you explain the triggering operation? I took another look at Figure 11; the IC1A is a 555 and IC1B is part of a 556. They are labeled correctly but the pin numbers are incorrect for a 556.

I need to say that I receive several electronic magazines and of them all, I really enjoy *Nuts & Volts* the most. Every issue has something that interests me. Thank you for being associated with such a great magazine.

— Al Izatt

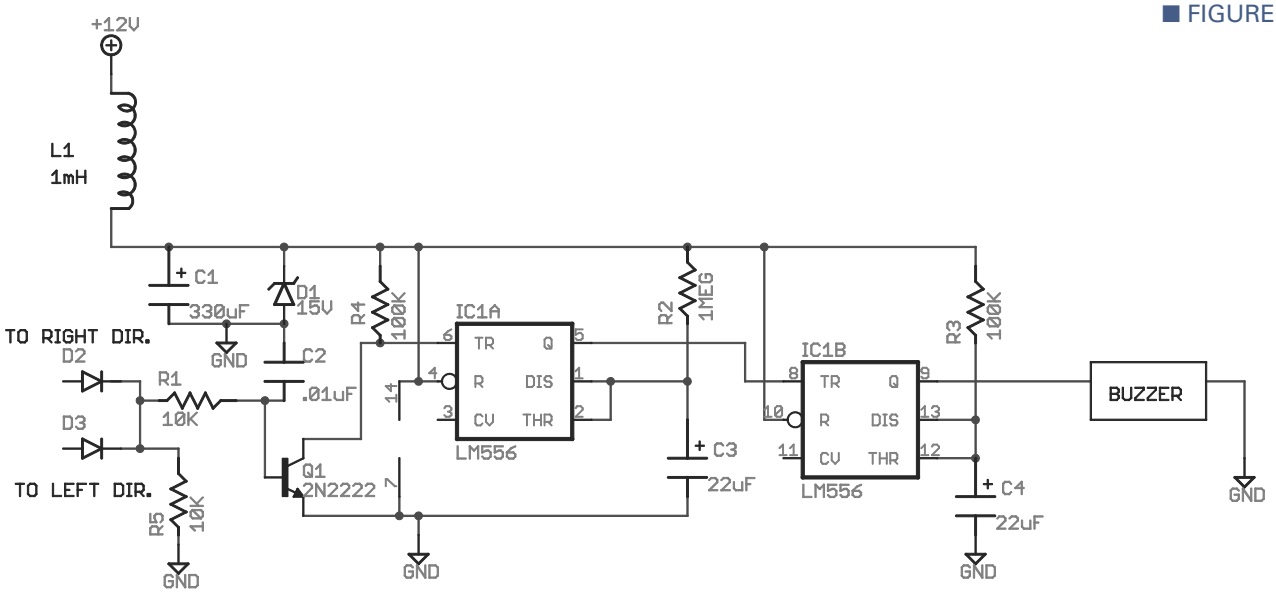
Response: You are right. I intended 1N4148 in Figure 7, but

Mailbag continued ...

there is no practical difference in this application. In Figure 11, the diodes are in error but turning them around won't fix it. The IC is triggered when the TR pin goes low, but since either right or left is always low, the circuit won't work. Turning the diodes around and inserting an NPN transistor will solve the problem (see Figure 5). The schematic symbol in the library is incorrect; I will modify it. Thanks for the kind words.

— Russell

■ FIGURE 5



goes dead. Is there any literature on hand that I could use (schematic) so that the cooler shuts down and there is enough amperage left to start my car?

— Leo

A The typical auto battery is 100 ampere-hours and the typical cooler draws 10 amps, therefore the battery will go dead in 10 hours or less. The timer in Figure 4 is designed for five hours. It starts timing when the power is turned on and shuts the cooler down when it times out. To restart, turn the power off and on again. IC4A and B are the oscillator of 116 Hz which, when divided by 2^{21}, gives an output pulse in five hours. The pulse from IC1 sets the flip-flop IC3A and turns the transistor switch, Q1, off. Pin 2 of IC3A is fed back to the oscillator to turn it off although it was not necessary to do so. C2 and R4 cause a reset of the flip-flop at power turn on to insure that the transistor switch is initially on. The LED will be lit when the cooler is cooling and will be dark when the timer has run out. **NV**

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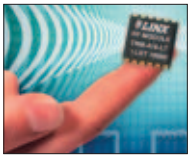

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This makes the modules capable of transparent serial data transfer at rates of up to 10 kbps over outdoor line-of-sight distances in excess of one mile. However, when the transmit power is set to the maximum allowed under FCC limits, that range will typically be reduced to 3,000 feet or less. Even applications not requiring long ranges will benefit from increased link reliability.

Data can originate from virtually any serial data source, including microcontrollers, RS-232, a Linx transcoder IC, or a Linx USB module. The modules are RoHS compliant and housed in a compact SMD package that is well suited to both prototyping and high-volume production. The transceiver is actually smaller than Linx LR Series receiver modules. The transceiver can also be utilized with existing Linx LC and LR Series transmitters and receivers, allowing for mixed mode and legacy configurations, as well as repeater capability for range extension.

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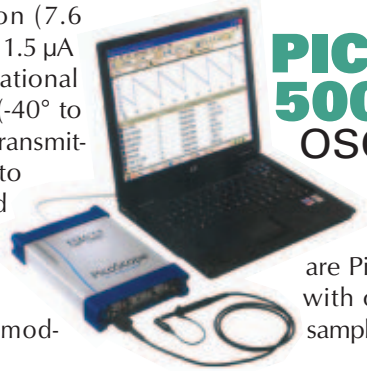

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The new advanced trigger types are part of a continuing program of upgrades for the PicoScope 5000 series scopes, which has recently seen the addition of an auto-setup command and a new spectrum view. The new trigger types are dual edge, window, pulse-width, drop-out, interval, and logic triggering.

Window triggering detects when signals go into or out of a given range, so is useful for finding overvoltages. Pulse-width triggering can recognize short or long pulses, so helps you find glitches and timing violations. The drop-out trigger finds the moment when a repetitive signal — such as a clock — goes dead. Interval triggering detects when two successive clock edges fail to meet a timing condition. Finally, logic triggering lets you trigger on practically any combination of up to four input levels or voltage windows.

If you're troubleshooting digital signals, you will be able to use these new trigger types to obtain a stable display of complex digital waveforms such as serial data streams and control signals. The PicoScope 5000 series scopes are ideal instruments for digital troubleshooting because of their high sampling rate and large buffer size which, when used together, allow you to capture long duration snapshots with high time resolution.

Alan Tong, Managing Director of Pico Technology, said "This is the latest in a series of improvements to the PicoScope 5000 series scopes and the PicoScope 6 software. Our customers can expect regular free upgrades to PicoScope 6 as we learn more about what they need from our products."

The latest PicoScope 6 upgrade with advanced triggering is available now for download — free of charge — from the Pico Technology website.

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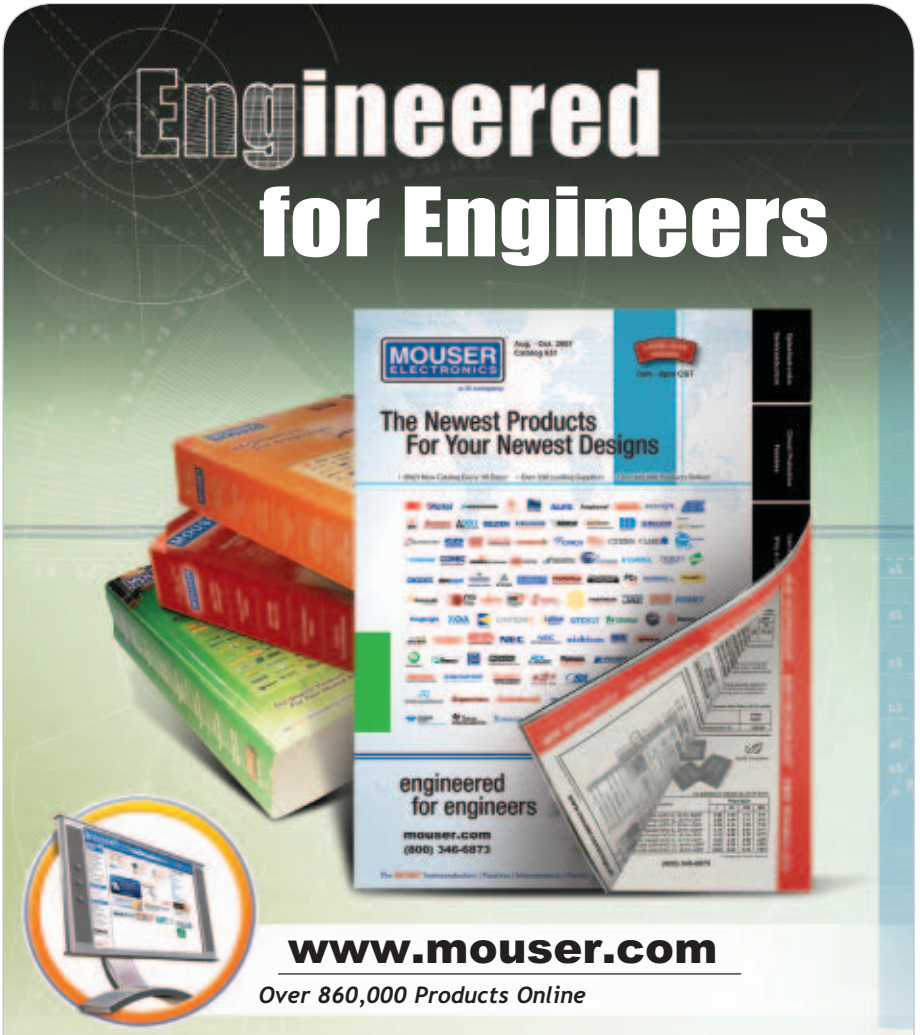

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AC/DC voltages from 100 µV to 1,000 V, AC/DC current from 400 µA to 10 A, and resistance from 0.1Ω to 40 MegΩ, the models also offer duty cycle, frequency, capacitance, diode check, and transistor test capabilities. The Model 6100 has a user price of $34.

Both units have "smart jacks" that light up to indicate appropriate input. The jacks flash and buzz to warn of current overload and/or incorrect inputs. Overload protection fuses may be reset without opening the meter case. Relative mode, data hold, as well as auto-power-off (sleep mode), add to the functional ease.

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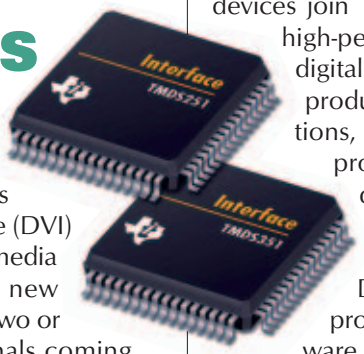
TWO HIGH PERFORMANCE HDMI SWITCHES



Texas Instruments has introduced two new video switches for digital video interface (DVI) or high definition multimedia interface (HDMI). The new devices connect either two or three digital video signals coming from devices such as game consoles, digital video switch boxes, set-top boxes, or DVD players to a single HDTV display (see **www.ti.com/tmds351-pr**).

Both the TMDS351 three-port switch and the TMDS251 two-port switch integrate four transition minimized differential signaling (TMDS) channels, one hot plug detector, and a digital display control interface on each port. Each TMDS channel supports signaling rates up to 2.5 Gbps to allow 1080p resolution in 12-bit color depth, making it compatible with the HDMI 1.3a standard. Switchable termination resistors (50 ohm) are integrated at each TMDS receiver input, eliminating the need for external terminations. Both devices share the same package and pinout allowing customers to easily and quickly develop common platforms for two and three HDMI inputs.

The new HDMI/DVI switches provide selectable receiver equalization to accommodate different input cable lengths, allowing longer cable reaches and improved opening of the data eye for better noise budgeting. Each device provides strong electrostatic discharge (ESD) protection at the connector by featuring 8 kV human body model (HBM) circuitry on the TMDS inputs.

These new switches support power saving operation. When a system is in standby mode and there is no transmission of digital audio/visual content from a connected source, the 3.3V supply voltage can be powered off to minimize power consumption from the TMDS inputs, outputs, and internal switching circuits.

The TMDS351 and TMDS251 devices join TI's extensive offering of high-performance analog and digital signal processor (DSP) products for video applications, including DaVinci™ processors optimized for digital video systems, the TVP7000/1 triple 8/10-bit video ADCs, and DLP® technology. TI provides the silicon, software, systems expertise, and support for customers' video designs, enabling them to accelerate market entry. For more information on TI's video products, see the Video and Imaging Solutions Guide at **www.ti.com/video**.

The TMDS351 and TMDS251 switches are available now in 64-pin TQFP packages.

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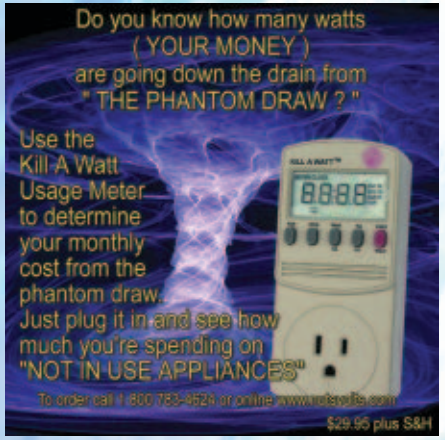

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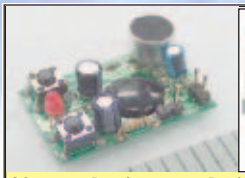

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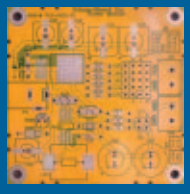

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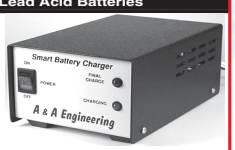

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I have been operating PSK-32 on my ham radio for about eight years now.

All of my interfaces between the radio and my PC have been homebrew. I am now on my third generation interface and believe that it will probably be my last. So far, I have not been tempted to use any of the newer digital audio interfaces since I still like analog control of the volume/level.

ANALOG: Mixed and Matched

The device described in this article is both a 4:1 audio mixer and a 1:4 distribution system. Each of the input and output channels has its own volume control. One mixer channel and one distribution channel are used for the interface to my transceiver and I have also installed a transmit/receive switch on the front panel. One other distribution channel drives the powered speakers of my PC.

Although I am using this system with my PC, any audio system which needs to expand its line level input and/or output capability can easily make use of it. The system is built using separate circuit boards for the mixer and distribution systems so that you only need to implement the part your system requires.

Circuit Descriptions

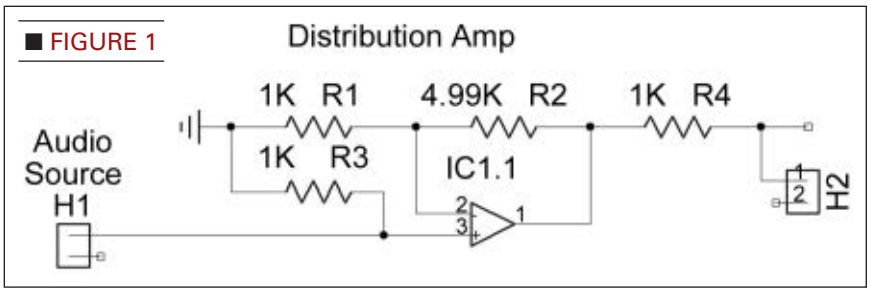
In the following discussions, only the left channel operation will be described since the right channel is identical in every case. In the case of the distribution and mixer blocks, the component references are to the first block. Each circuit description contains a simplified schematic. Additional files (including assembly files showing placement of all components) are available on the *Nuts & Volts* website (**www.nutsvolts.com**) and on my website at **WWW.QSL.NET\K3PTO**. I have also posted the Gerber PCB files in case anyone wants to have their circuit boards made elsewhere.

Distribution Amplifier

The distribution amplifier is a "follower with gain" circuit (Figure 1) which multiplies the input signal by a factor of approximately 6 and is defined by the formula R2/R1 + 1. The purpose of R3 is to keep the positive input of the dual op-amp from floating and to insure that it is biased to ground when there is no input connected. The purpose of R4 is to isolate the output of the amplifier from the gain controls of the four distribution blocks (see Figure 2).

Since each distribution block has a 5K potentiometer, the total parallel resistance "seen" by each channel is about 1.25K. This causes the total gain of the amplifier — from the input to the top of the

FIGURE 1

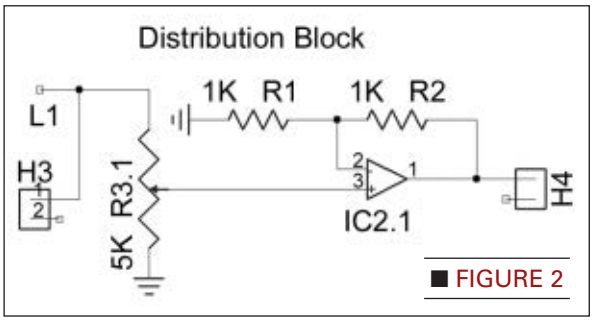


potentiometer — to be about 3.3.

Distribution Blocks

The circuit for the distribution block is another follower with gain circuit (Figure 2). The gain is set to 2 by the formula of R2/R1 + 1. This makes up for the gain reduction due to the potentiometers in parallel (see full schematic).

The output header (H2) of the distribution amp and the input headers (H3, etc.) of the distribution blocks allow you to implement a switch between them, if desired (see block diagram). The traces on the circuit board connect all of the left channel inputs to the left channel output of the distribution amplifier. The right channel is wired identically. It is not difficult to cut those traces with either an X-acto™ knife or a Dremel™ tool. If you use all four distribution blocks, you will need a two-pole four-position switch (see Schematic 1).



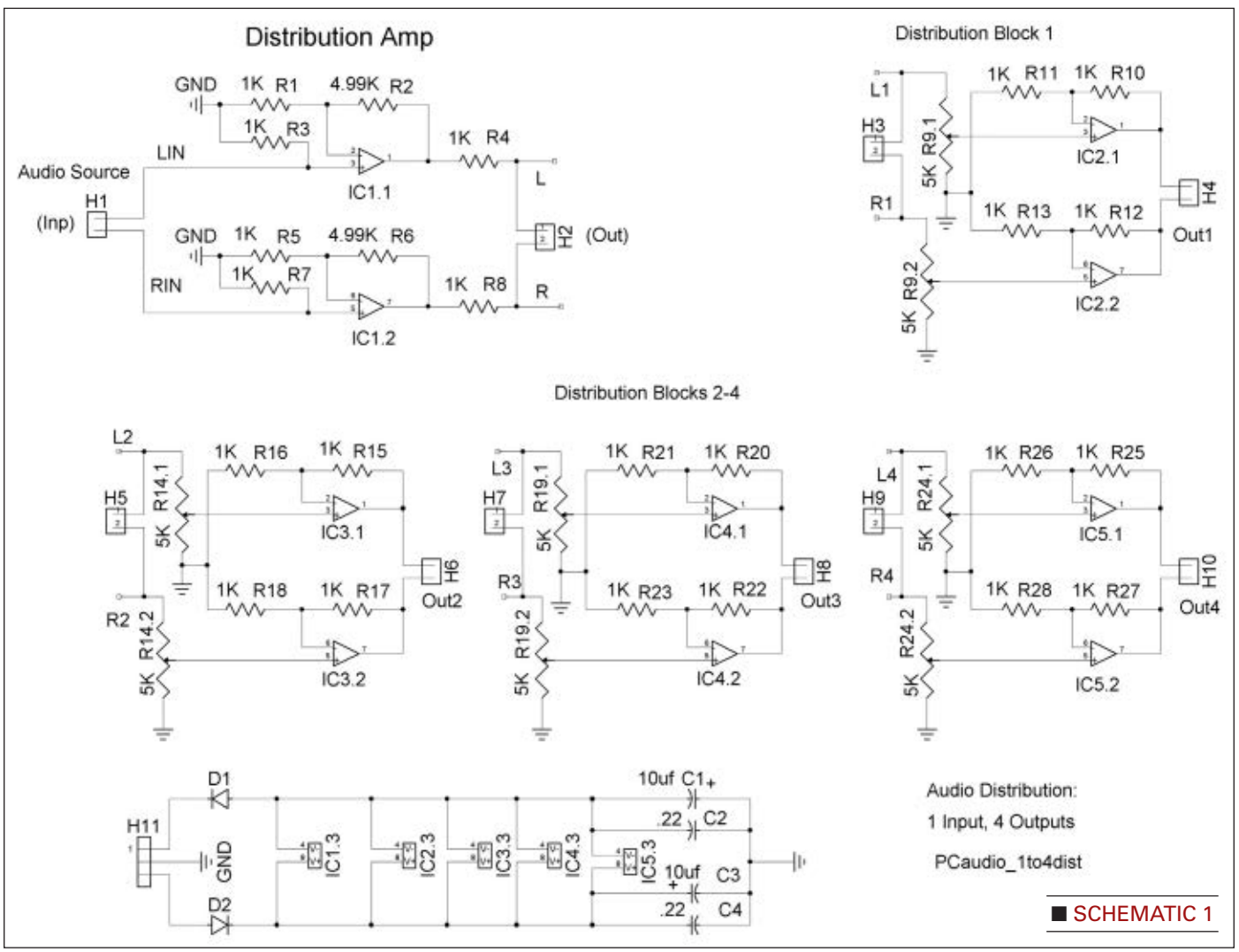
■ FIGURE 2

Mixer Blocks

The mixer blocks (Figure 3) are also followers with gain. The gain is approximately 6 and is set by the formula R2/R1 + 1. R3 is there to equalize the offset voltage, as well as to provide some protection for the input. R4 is to keep the input from floating when there is no input connected.

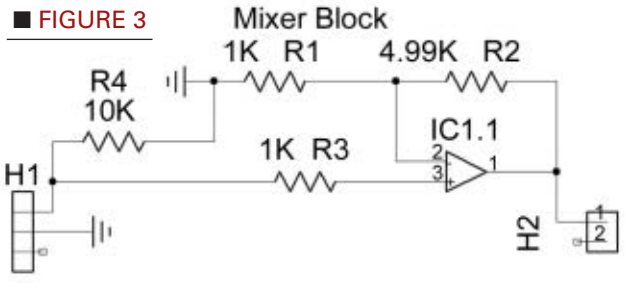
Mixer Amplifier

Both channels of the mixer amplifier have four inputs (one input shown) consisting of four potentiometers (5K) and four sets of 10K resistors and is a typical inverting amplifier circuit. The gain of the mixer amplifier is about -1 and is set by the formula

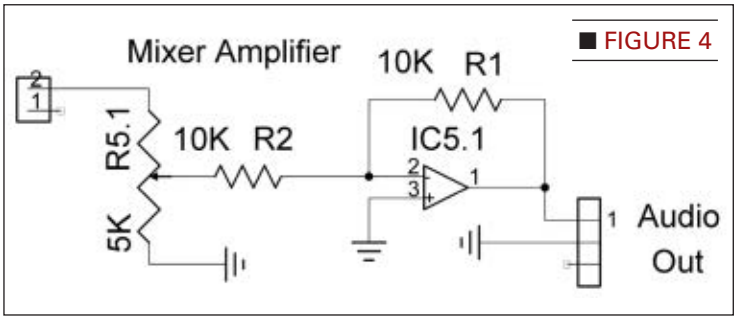


■ SCHEMATIC 1

■ FIGURE 3



■ FIGURE 4



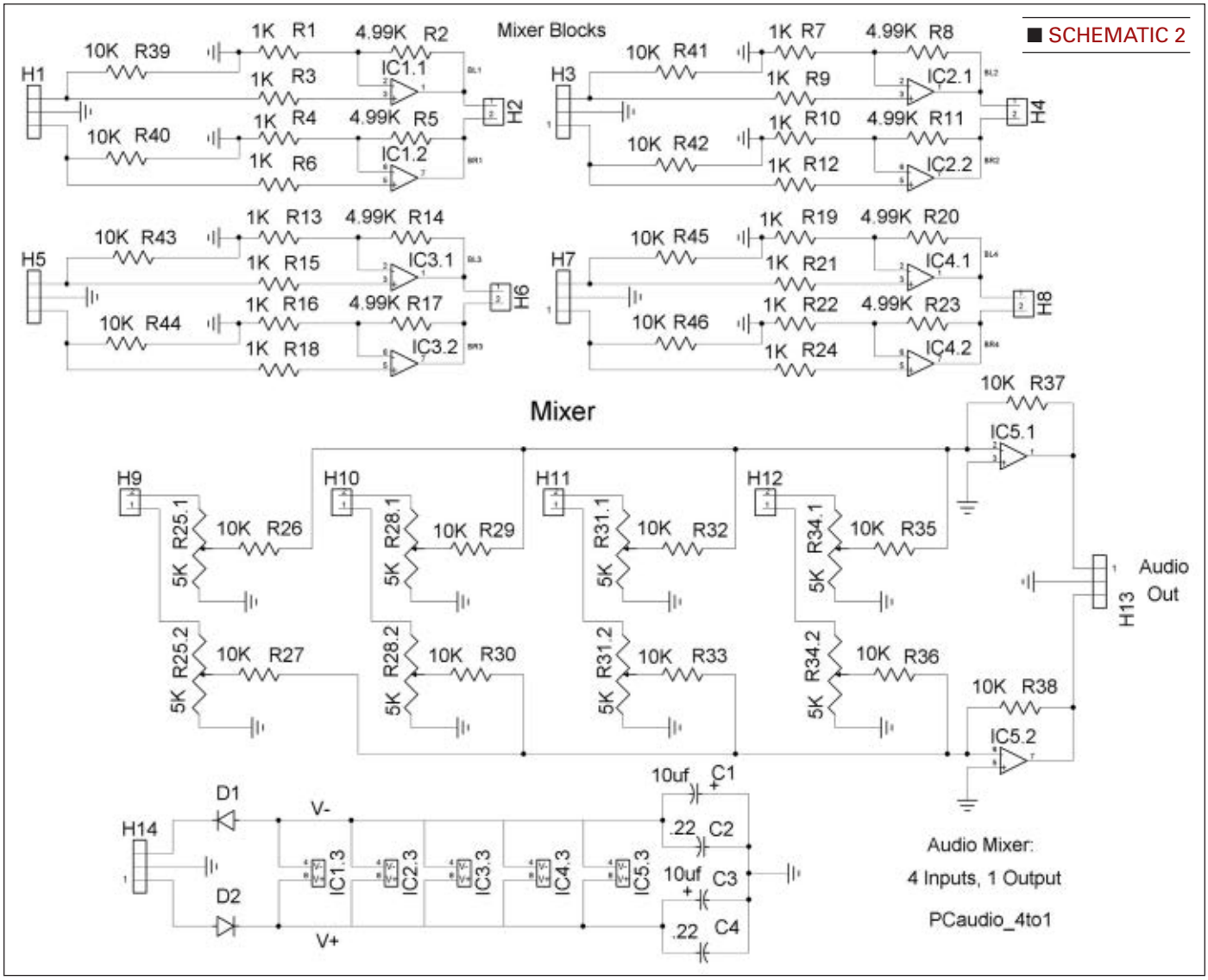
-R1/R2. The mixer sums (and inverts) each of the four inputs. There is going to be some interaction between the position of the wiper on the pot and the 10K resistor since they are roughly the same magnitude. For practical purposes, that interaction can be ignored.

I chose an op-amp inverter for this circuit because it enables each of the summing resistors (R2, etc.) to work into a virtual ground. This gives complete isolation among the four volume controls used on the mixer blocks.

The main reason why the potentiometer is part of the mixer amplifier rather than the mixer blocks is that if a switch is used, I did not want the low level output of the potentiometer to be switched. This wiring allows the high level signal to be switched instead.

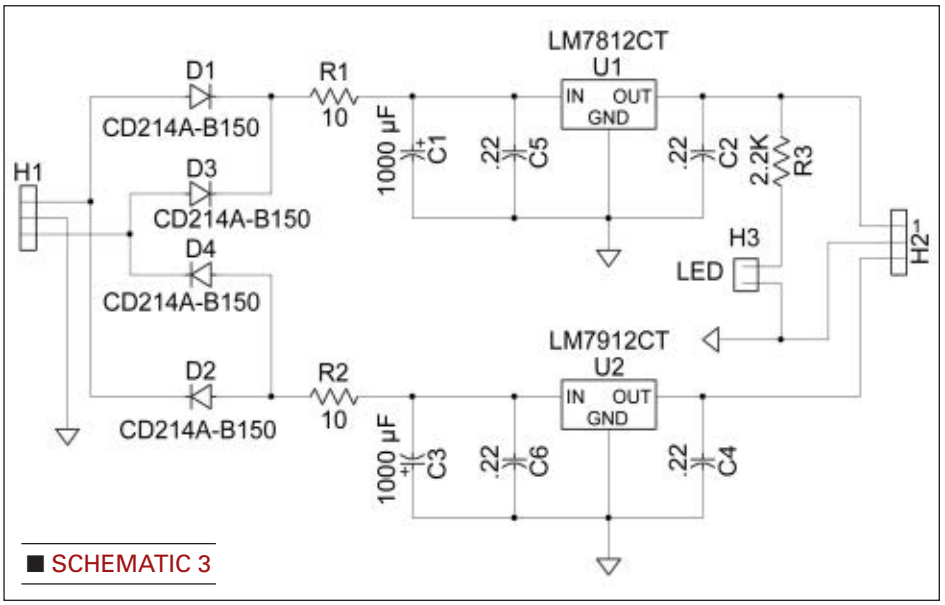
In the same way as the distribution blocks, the mixer blocks are

■ SCHEMATIC 2



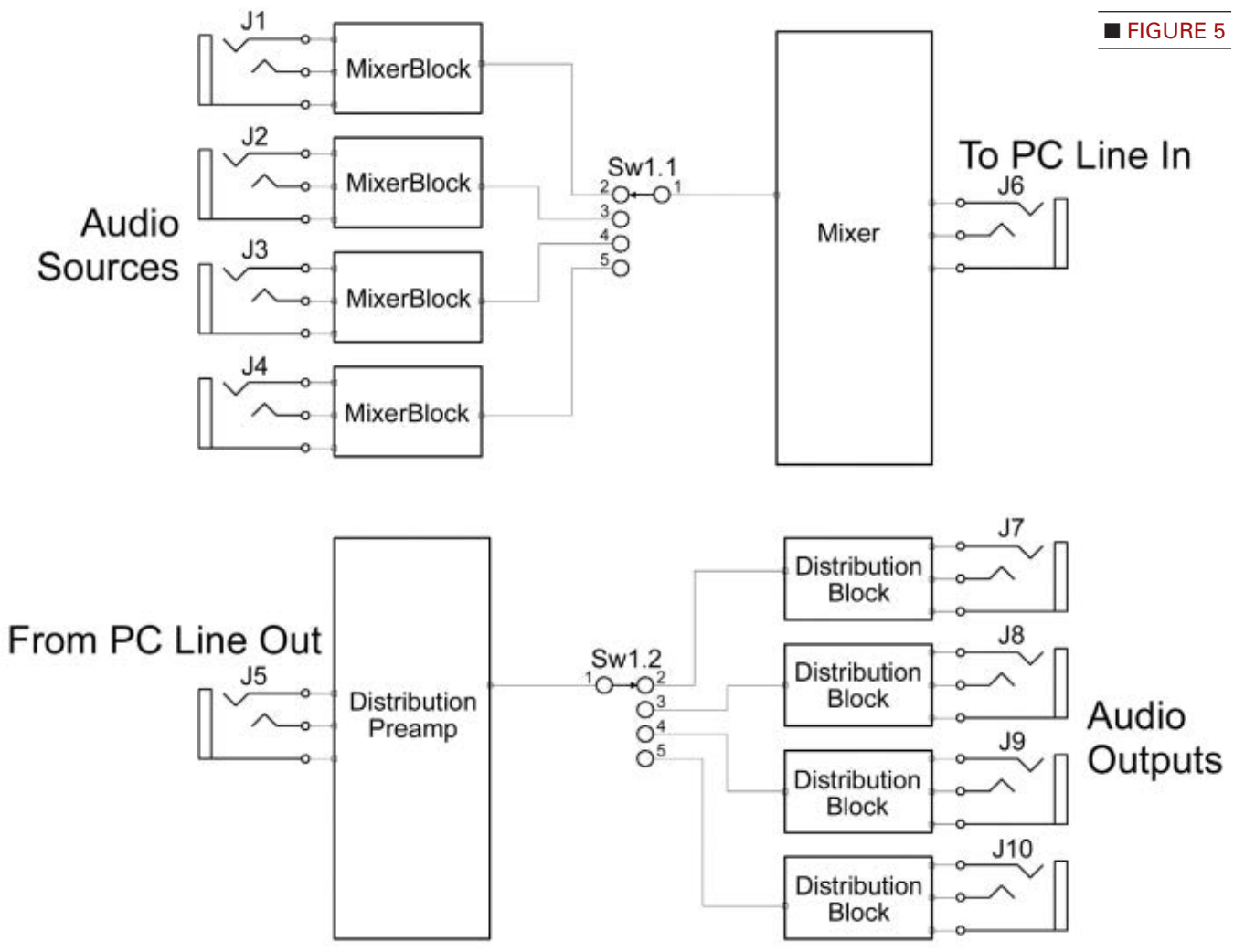
wired to the inputs of the mixer amplifier. They can be cut and a switch inserted, if desired. Also, if you have a signal with a high enough level and can tolerate a 5K load, you can bypass the mixer block altogether and connect directly to the top of the potentiometer.

A general note for each of the above systems: You can customize the gain values per channel if your application would benefit simply by changing the resistor ratios. I would change the resistor connected between the op-amp output and its input. Also, there is a practical limit before the circuit will become unstable. I suggest that the gain NOT be increased enough to



■ SCHEMATIC 3

■ FIGURE 5



The switch is actually a 4Pole-4Pos Sw., so it can switch both the L and R channels.

handle microphones. Most mics have outputs in the range of about -60 dbm (about 1 mv at 600 ohms). This is quite a low level signal and more care needs to be exercised in order to amplify this level than I have taken with this implementation (see Schematic 2).

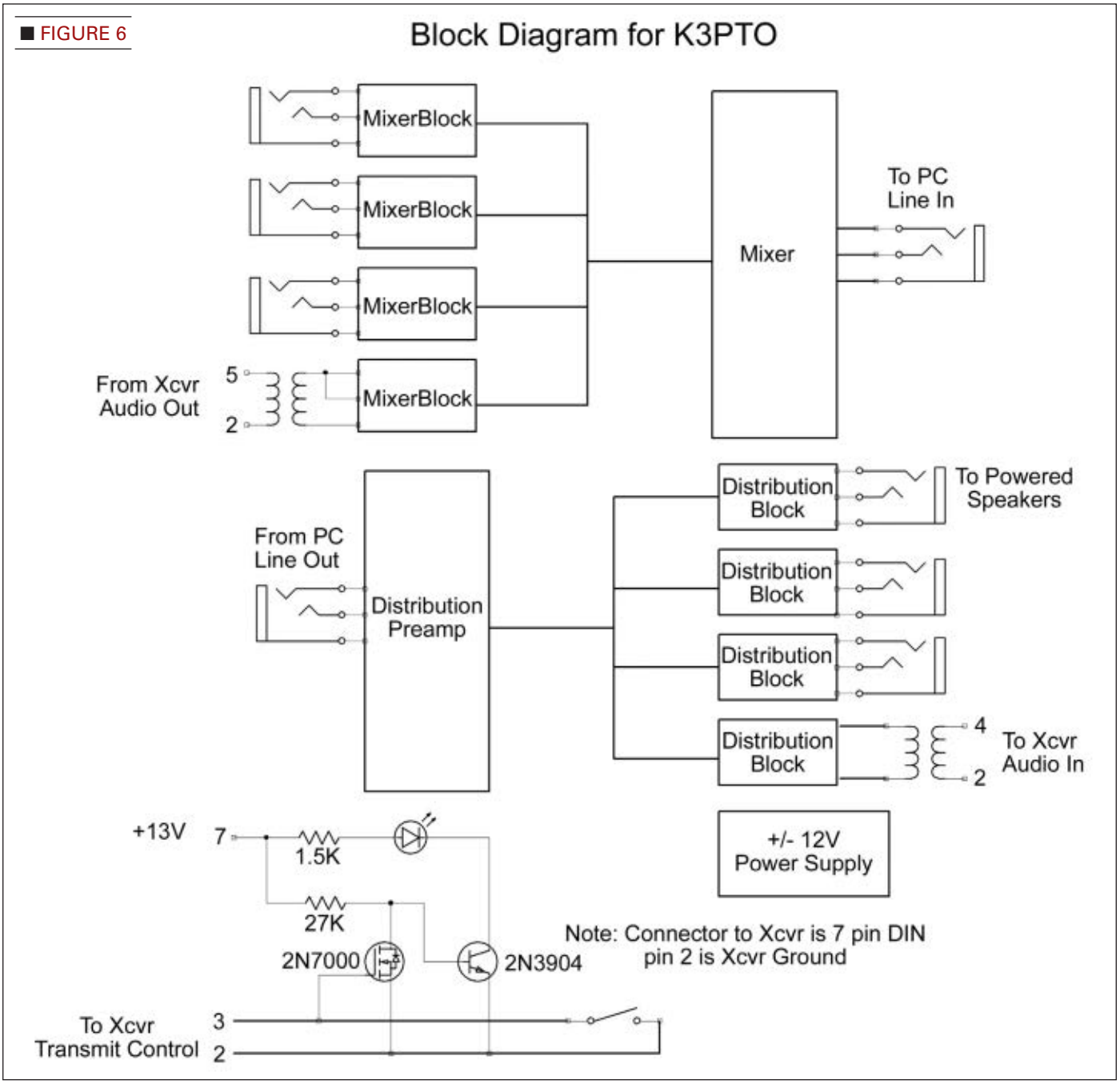
Power Supply

Refer to Schematic 3. The power supply I implemented is powered by a 20 VAC wall-wart. I strongly recommend the use of a wall-wart or external transformer in order to keep AC mains outside of the box. The supply circuit I built consists of two half wave rectifiers and 12 volt regulators. There is provision on the board for a full wave rectifier if you use a transformer with a center tap. The value of the two series resistors — 10 ohms on my board — should be selected based on the voltage source. Just make sure that their power rating is sufficient.

Ideally, the resistors should drop enough voltage so that the regulators are presented with about five volts above their output voltage. This will help minimize the regulators' power dissipation, as well as provide better filtering of the rectified AC input. The two audio boards draw a total of about 100 mA.

Due to the symmetry of the

■ FIGURE 6



system, the same current flows through both the positive and negative supplies. I used 12 volt regulators simply because I have a number of them on hand. I believe that either nine or 15 volt regulators would work equally well.

Assembly

The case I purchased (see the bill of materials) has fairly soft aluminum so I had to be careful drilling it in order to not bend it out of shape. I also mounted a rectangular piece of wood (1/2″ x 1/2″ x 5″) to the top of the inside cover so that the back surface has some bracing when inserting connectors. Most of the connectors are standard 1/8″ dia. stereo types. The ones I used are isolated, except the ones to and from the PC, but that is not really necessary. Since one input and output channel goes to my ham radio transceiver, I decided to use a single, seven-pin connector for its interface. Obviously, you can use whatever connectors are appropriate for your application.

I used 0.1″ single row connectors for making the various connections. Each connector housing needs to be cut to length. This is easily done with a utility knife. The cost of using this method is about $0.15 per connection. I believe that the added cost is well worth the flexibility it provides. I can completely disconnect any of the subsystems without having to unsolder wires.

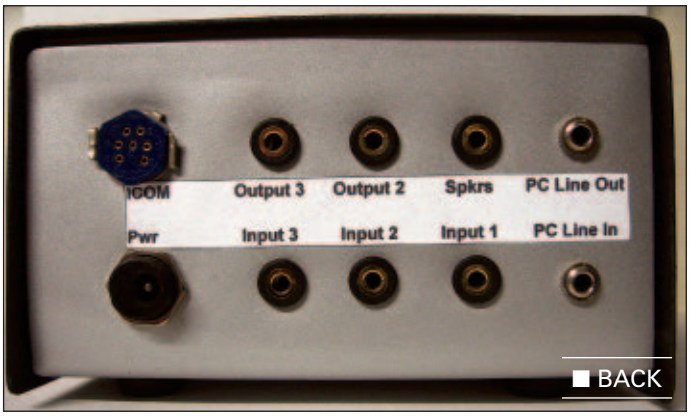
The hardest part of using the connectors is that each of the wires is terminated with a crimp pin. I happen to have access to a hand crimper tool that made it relatively easy for me. However, I have hand crimped many of them in previous projects. For hand crimping, I would work under a lighted magnifying lens and use a pair of small, curved nose, needle-nose pliers. One hint for hand crimping: Leave the pin on the strip while crimping the wire.

One minor problem I encountered was with the knobs for the pots. The pots have 1/4″ shafts and the knobs were supposed to be for 1/4″ shafts. However, they turned out to be for fluted shafts (probably my mistake). I had to partially drill out the fluting in the knobs to make them fit. I suggest you try to find knobs with set screws.

PARTS LIST

ITEM	VALUE	QTY	SUPPLIER/PART NO.
Distribution Amp:			
❑ C1,C3	10 µF	2	Mouser/80-T491B106K020
❑ C2,C4	0.22 µF	2	Mouser/581-08053C224M
❑ D1,D2	CD214A-B150	2	Mouser/652-CD214A-B150
❑ IC1-IC5	LM833	5	Mouser/511-LM833D
❑ H1-H11	Pin Headers	23 pins	Jameco/160882
❑ R1,3-5,7,8, 10-18,20-23,25-28	1K	22	Mouser/292-1.0K-RC
❑ R2,R6	4.99K	2	Mouser/292-4.99K-RC
❑ R9,R14,R19, R24	5K dual pot	4	Mouser/313-1240F-5K
	Knob	4	Mouser/450-AE141
Mixer			
❑ C1,C3	10 µF	2	Mouser/80-T491B106K020
❑ C2,C4	0.22 µF	2	Mouser/581-08053C224M
❑ D1,D2	CD214A-B150	2	Mouser/652-CD214A-B150
❑ IC1-IC5	LM833	5	Mouser/511-LM833D
❑ H1-H14	Pin Headers	34 pins	Jameco/160882
❑ R1,3,4,6,7,9,10, 12,13,15,16,18,19, 21,22,24	1K	16	Mouser/292-1.0K-RC
❑ R2,5,8,11,14, 17,20,23	4.99K	8	Mouser/292-4.99K-RC
❑ R26,27,29,30, 32,33,35,36,37, 38,39,40,41,42, 43,44,45,46	10K	18	Mouser/292-10K-RC
❑ R25,28,31,34	5K dual pot	4	Mouser/313-1240F-5K
	Knob	4	Mouser/450-AE141
Power Supply			
❑ D1,D2	CD214A-B150	2 or 4	Mouser/652-CD214A-B150
❑ R1,2 (see text)	22, 1/2W	2	
❑ R3	2.2K	1	Mouser/292-2.21K-RC
❑ C1,C3	1000 µF	2	Jameco/93841
❑ C2,C4,C5,C6	0.22 µF	4	Jameco/544358
❑ U1	LM7812CT	1	Jameco/51481
❑ U2	LM7912CT	1	Jameco/51334
❑ H1,H2	Pin Headers	8 pins	Jameco/160882
❑ LED	LED	1	
System			
❑ Enclosure		1	Mouser/40UB103
❑ 3.5 mm Phone Jacks		10	Mouser/161-7300-EX
❑ 3.5 mm Phone Plugs		10	Mouser/171-2035
❑ 2.5 mm DC Pwr Plug		1	Mouser/171-0725
❑ 2.5 mm DC Pwr Jack		1	Mouser/161-0725-E
❑ Power Switch		1	
❑ AC Wall Wart		1	Jameco/421585
❑ Pin Headers		40 pins	Jameco/160882
❑ Socket Housing		36 pins	Jameco/103158
❑ Socket Pins			Jameco/100766
❑ Circuit Boards		1 set	FAR Circuits

■ FRONT



■ BACK

Both the mixer and distribution boards are mounted to the front of the case using only the pot shafts. This seems to be quite adequate. The power supply board is mounted using a single 4-40 screw through the bottom of the case with spacers between the inside surface and the bottom of the board. There is a copper ring around the hole for this bolt which is used to ground the board to the case.

Final Comments

I typically get my circuit boards made by FAR Circuits. They do not have plated-through holes so the leads of some components are used to connect the top side and bottom side traces. I strongly suggest you use a soldering iron with a fairly fine tip and small diameter solder so you do not wind up heating two or more pins of the SMD op-amps at one time.

I also find it helpful to work using a magnifying lens with a lamp. Mine is 3X, but there are times I wished it was 5X.

I have included two block diagrams showing possible implementations of the audio center (see Figures 5 and 6). Keep in mind that, although I am using this with my PC, the system can be used with any sound system desiring this type of expansion. **NV**

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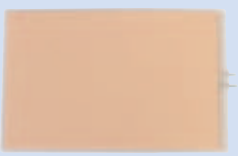

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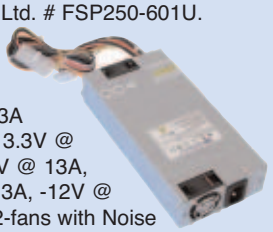

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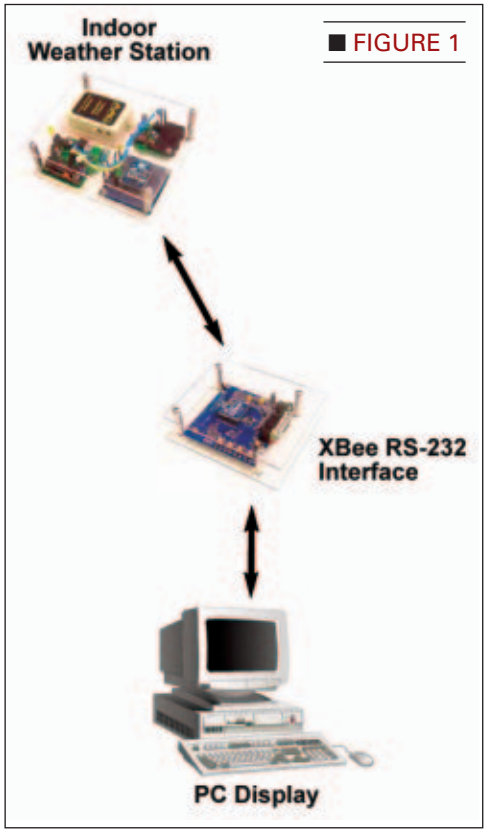
Build a Wireless Weather System: Part 2

In this installment of the wireless weather station, I am going to show you how to build the Indoor Weather Satellite.

Once assembled, we will run some tests with our PC interface satellite as shown in the network diagram in Figure 1.



■ FIGURE 1

You should have the Maxstream mesh network firmware installed in each of the XBee modules you plan on using in your wireless network as outlined in Part 1 of this project. Using the Maxstream USB and RS-232 development boards, you should have performed some basic tests to make sure your XBee modules are properly configured.

Building the Indoor Weather Satellite

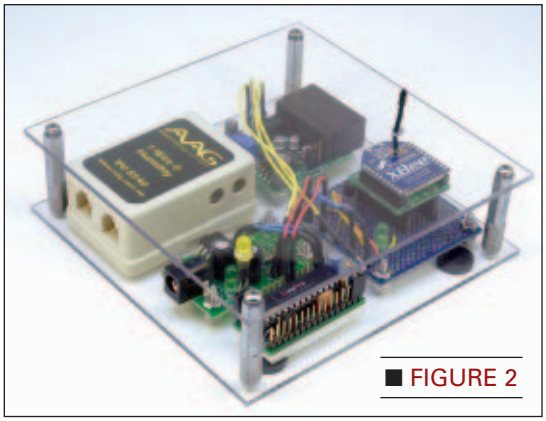
The indoor satellite has a couple of functions to perform. Since the XBee module has been configured as a coordinator, its main job is to give all the other satellites a place on the network as they are added. It also serves as our main indoor data collection point. Here, we will collect barometric pressure, indoor humidity, and indoor temperature. I will be using the AAG humidity sensor, Hobby Boards pressure sensor, and a DS1820 to collect temperature data. For the wireless side of things, I chose to use a standard XBee module and SparkFun's breakout board. A small regulator module and a DiosPro 28 from KronosRobotics will also be used to power and control everything. All these items will be attached to two pieces of plastic and connected with SchmartBoard jumpers as shown in Figure 2.

As we build this satellite, you can refer to Schematic 1 for detailed connection information.

• *STEP 1:* You will need two pieces of acrylic as shown in Figure 3. The size I used was 5″ x 5″. A little larger size won't hurt, but I would not cut them any smaller. I also drilled a 5/32″ hole into each corner of one piece. I then used that piece to mark and drill the second. This will insure that the holes line up when you add the standoffs later.

(As we proceed, refer to Figure 11 for the actual layout of all the assembled components and sensors. I recommend you assemble all the kits, dry fit, and mark them before final assembly.)

• *STEP 2:* You need to assemble a Dios Carrier 1 board according to the included instructions, with



■ FIGURE 2

FIGURE 3

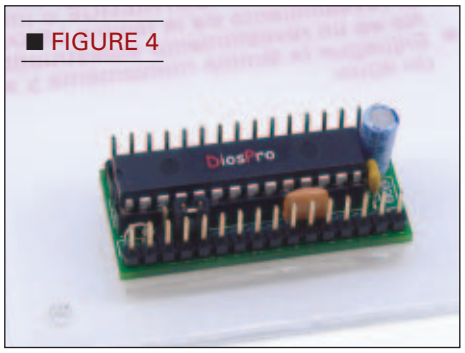


FIGURE 4

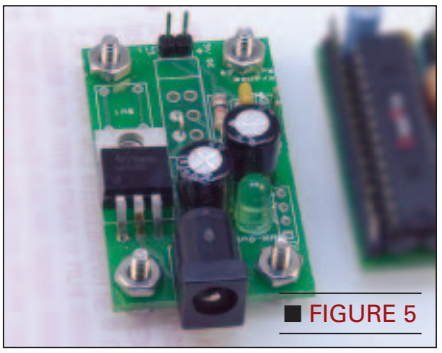


FIGURE 5

the exception of the two, 16-pin headers. For this project, you need to install the headers on top of the board as shown in Figure 4. Use two layers of double stick foam tape to attach the carrier to the base, and then install the Dios Pro chip as shown.

Note: If you plan on programming the DiosPro while the top piece of acrylic is in place, you need to place this module closer to the edge of the acrylic. This will allow you to plug in the EZRS232 board.

• *STEP 3:* Assemble the Kronos Robotics five-volt regulator board and attach it to the base. To do this, place the regulator on the base and mark the location of the four holes. Drill four 5/32 holes on the marks, then install #4 machine screws and nuts as shown in Figure 5. Next, slip the regulator over the screws and add four more as shown in Figure 6.

• *STEP 4:* You have three assembly choices for the wireless module. The purpose of this is to provide a 3.3V to 5V interface, as well as a way to attach and secure the XBee module. The actual assembly instructions for each version are available at:

• SchmartBoard 2mm proto board (Figure 7a) — **www.kronosrobotics.com/Projects/MaxStreamInterface2.shtml**

• SchmartBoard .1″ protoboard and SparkFun breakout board (Figure 7b) — **www.kronosrobotics.com/Projects/MaxStreamInterface3.shtml**

• KronosRobotics 3.3V-5V interface and SparkFun breakout board (Figure 7c) — **www.kronosrobotics.com/Projects/MaxStreamInterface4.shtml**

I used the .1″ proto board shown in Figure 7b, but all will work. The 2 mm SchmartBoard shown in Figure 7a will require that you attach a standard .1″ header to the top of the 2 mm headers in order to use the jumpers.

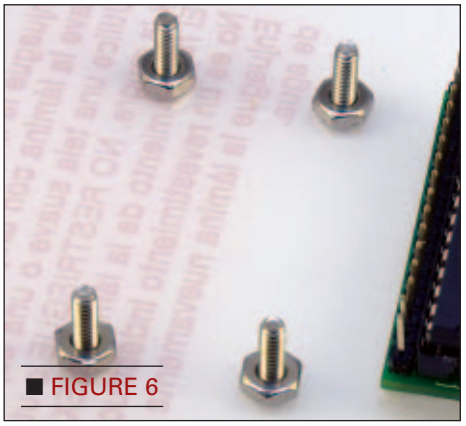
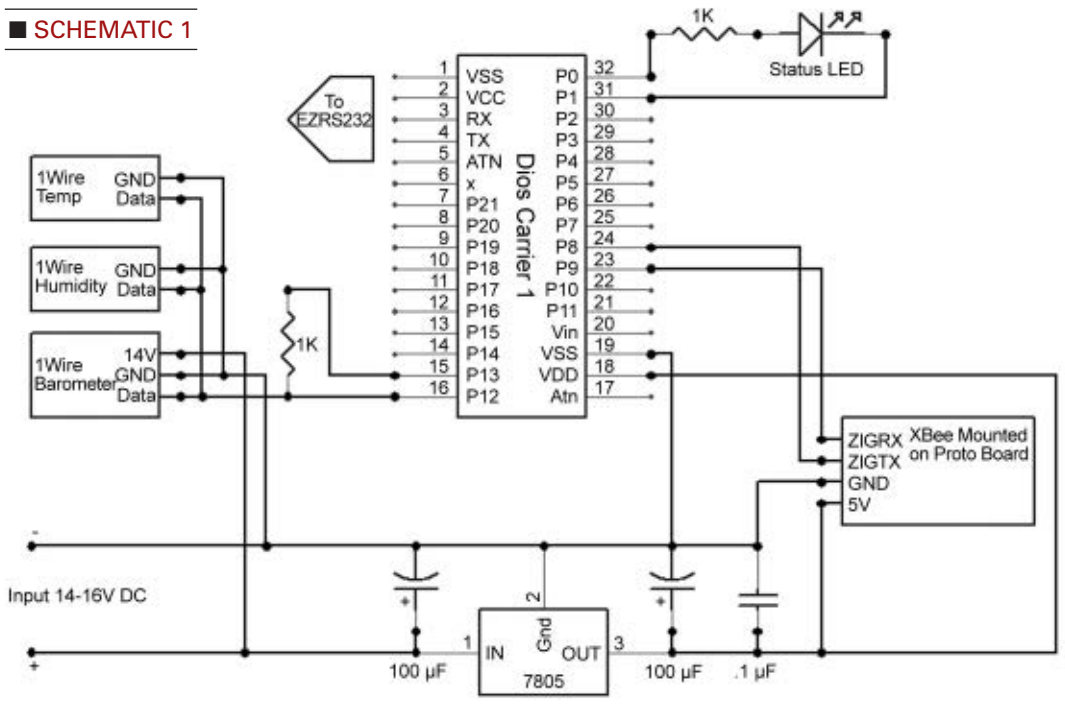
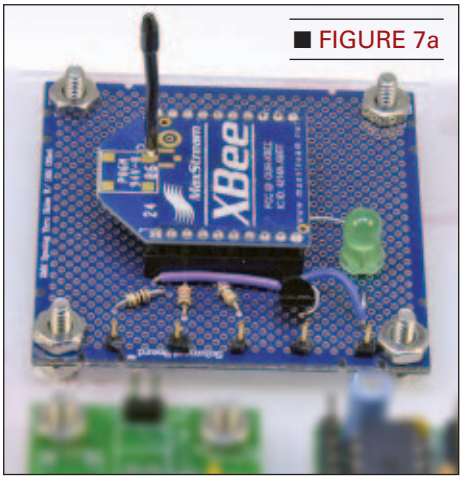


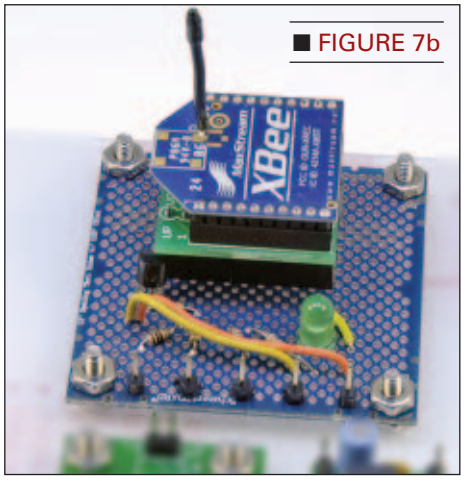
FIGURE 6

SCHEMATIC 1

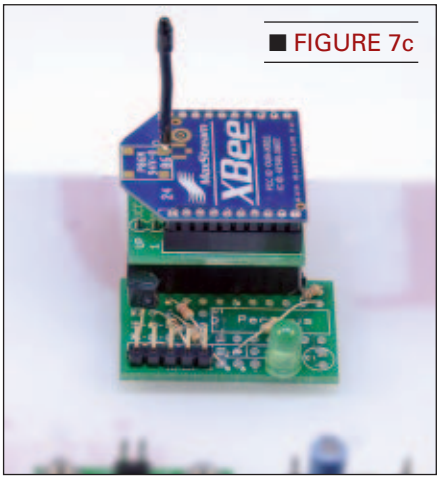




■ FIGURE 7a



■ FIGURE 7b



■ FIGURE 7c

• *STEP 5:* You will need to prep the Hobby Boards 1Wire pressure sensor so that you can attach the jumpers later. To do this, break off a male header and remove the plastic from the pin. You can use straight or right angle headers for this as shown in Figure 8. Later, we will be inserting jumpers on these pins.

If you are going to connect an indoor humidity sensor, you will need to connect two 4" wires to the headers shown in Figure 8. These will route to the humidity sensor when we install it later. If you wish, you may use different colors for the wires.

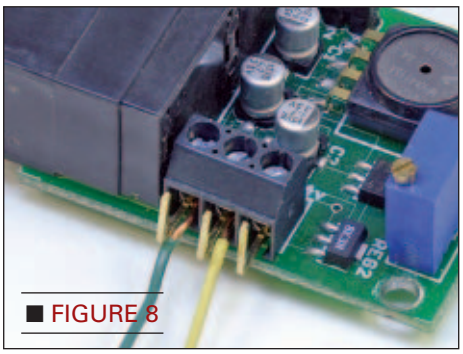
• *STEP 6:* The pressure sensor only has two mounting holes and the tolerance between the hole and the other components is quite close. I marked the holes and attached two #4 machine screws and nuts to the base, then attached the pressure sensor to machine screws. Because of the tight tolerance, I used some rather thin #4 standoffs to attach the board as shown in Figure 9. You can also attach the sensor with two layers of double stick foam tape.

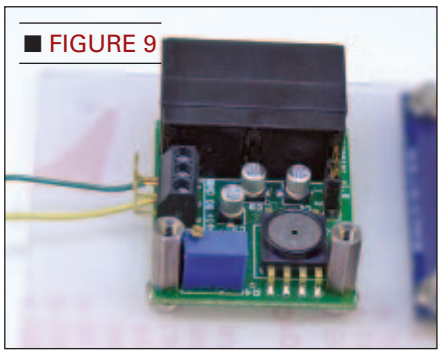
• *STEP 7:* If you are using the humidity sensor, you have two choices in mounting. You can use two #4 machine screws or double stick foam tape. To access the mounting holes, you need to remove the PCB (printed circuit board) first. This is held in place by the four small terminal screws.

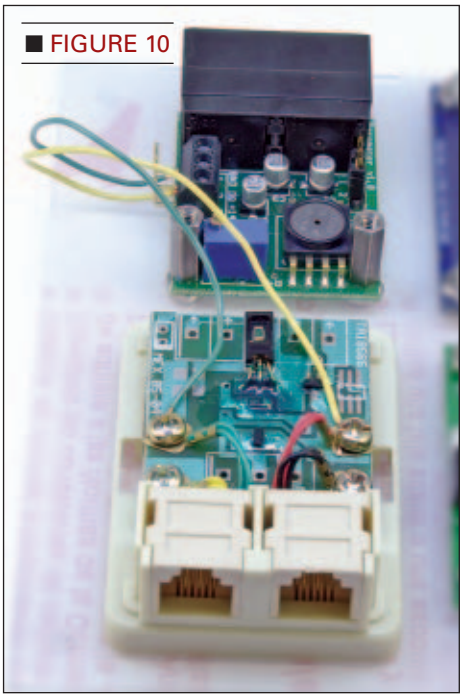
Note that the Hobby Boards humidity sensor will work, as well. Once mounted and connected, its operation is identical to that of the AAG sensor.

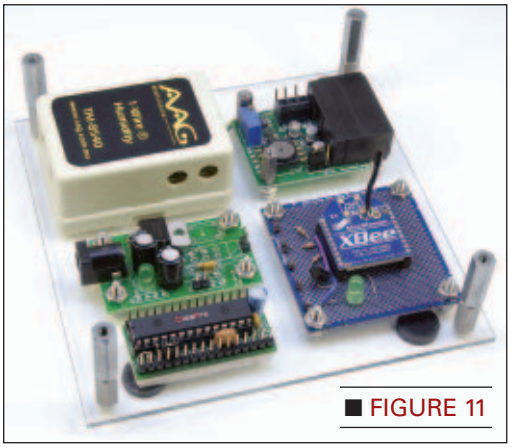
Next, you need to connect the two wires from the pressure sensor to the humidity sensor. The green wire (Gnd) is connected to the green terminal on the humidity sensor. The yellow wire (DQ) is connected to the yellow terminal on the humidity sensor as shown in Figure 10. If you are using the Hobby Boards sensor, it is a bit easier. Connect the Gnd and DQ terminals on the pressure sensor to the Gnd and DQ terminals on the humidity sensor.

• *STEP 8:* All components for the indoor satellite are now in place as shown in Figure 11. Attach four 1-1/4" #4 standoffs to the bottom base as shown in Figure 11. You can use single standoffs or combinations. You may also use larger standoffs if you want more clearance. At this point, I also mounted four rubber feet on the bottom of my base, as well. Just about any will do. I purchased these from my local home center.

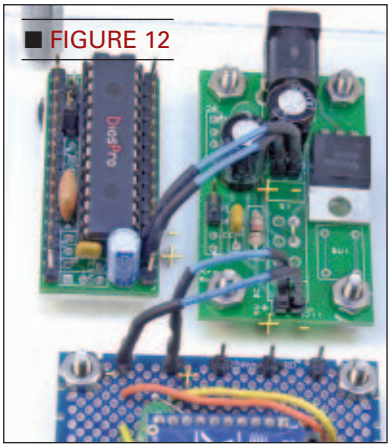

■ FIGURE 8


■ FIGURE 9

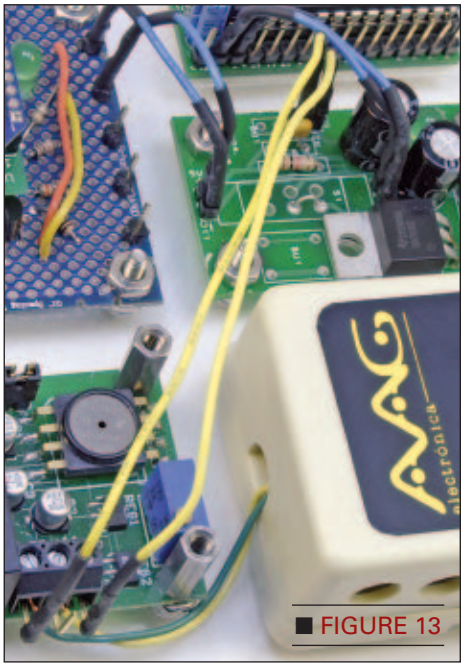

■ FIGURE 10



■ FIGURE 11



■ FIGURE 12



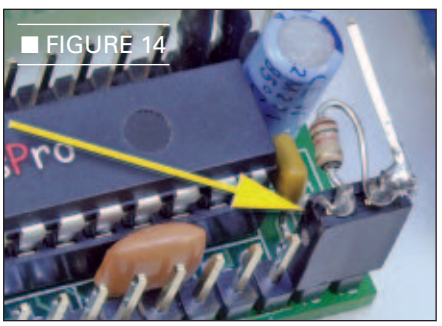
■ FIGURE 13

• *STEP 9:* Using jumpers, connect the + and – terminals on the regulator to the Dios Carrier 1 board as shown in Figure 12. If you are not clear on the actual pins, refer to the included hookup sheets.

Next, connect the + and – terminals as shown in Figure 12 to the XBee module.

• *STEP 10:* Attach the VIN terminal on the regulator to the +14V terminal on the pressure sensor as shown in Figure 13. Then connect the Vss terminal on the regulator to the Gnd terminal on the pressure sensor as shown in Figure 13.

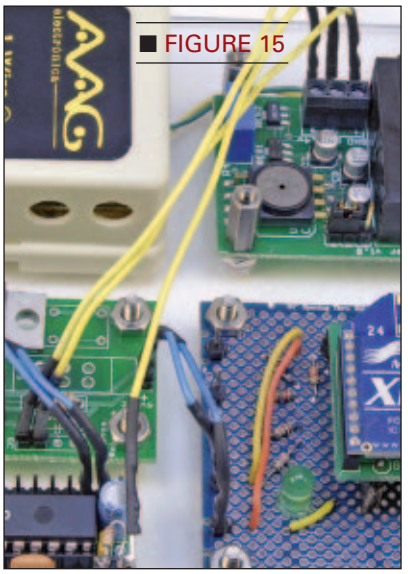
• *STEP 11:* Using a small two-pin female header, attach a 1K resistor between the two pins. Then attach a single male header to one of the pins as shown in Figure 14. Slip this assembly over the Carrier 1 header ports 12 and 13. Make sure the header pin that you added to the connector is on port 12. The resistor is used to hold the port 1Wire network high. Later in our software, we will set port 13 as an output and to a high state. This will supply the voltage needed to the resistor which will, in turn, supply the network.

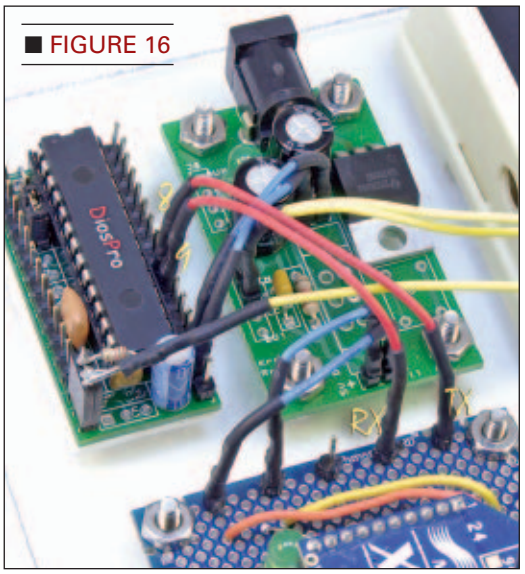

■ FIGURE 14

• *STEP 12:* Run a jumper from the pressure sensor DQ terminal to the port 12 header as shown in Figure 15.

• *STEP 13:* The last two jumpers connect the transmit and receive leads on the XBee module to the DiosPro chip. Connect the TX lead on the XBee module to port 8 on the Dios Carrier. Connect the RX lead on the XBee module to port 9 on the Dios Carrier (Figure 16).

• *STEP 14:* In order to perform tests and to supply a status LED for the satellite, we need to attach an LED to the DiosPro microcontroller. To create this LED, wire a standard LED in series with a 1K resistor to a two-pin female header as shown in Figure 17. The location of the resistor does not matter. You may also want to add a small amount of heat shrink, depending on the length of your LED leads. Attach the header to the Dios Carrier header ports 0 and 1. The flat side of the LED connects to port 0 as shown in Figure 18.


■ FIGURE 15



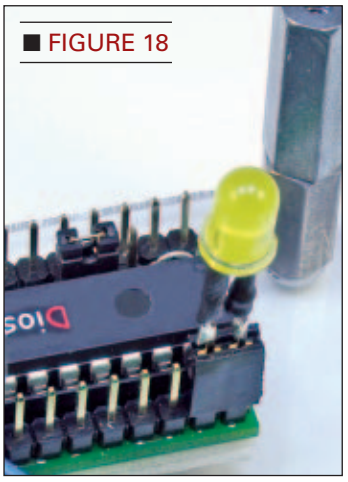
■ FIGURE 16

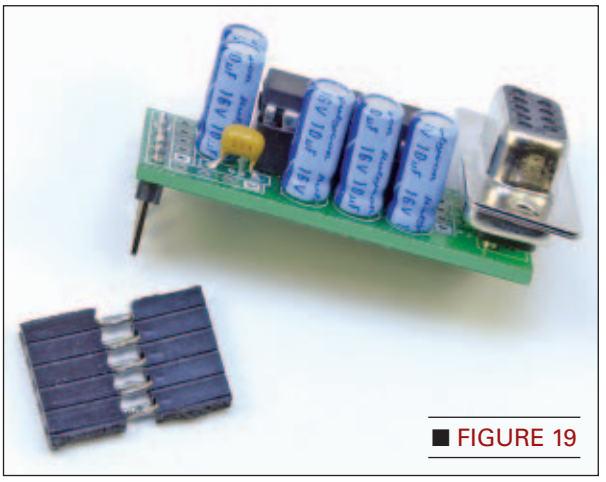
Testing the Indoor Satellite

You will need to use an AC

■ FIGURE 17

■ FIGURE 18





■ FIGURE 19

adapter that supplies 14 volts in order to supply enough power to the pressure sensor. I used a 12 volt unregulated AC adapter for this. When you apply power to the 5V regulator, the LED on the regulator should light up. If it does not or is very dim, then you have a bad power connection somewhere. Disconnect the power immediately.

The DiosPro ships with a test program installed on the chip. When power is applied, the status LED should blink. This indicates that the chip is getting enough power.

In order to program the DiosPro chip, you need an RS-232 adapter to connect the chip to your PC. These are available from the Kronos Robotics website for under $10. The EZRS232 interface comes in kit form with a five-pin male header. In order to connect the EZRS232 to our Carrier 1, we need to create a small adapter by connecting two five-pin female headers together as shown in Figure 19.

As an option, you may forgo the male header and attach a five-pin female header in its place as shown in Figure 20. This is the preferred method of programming the Dios Carrier 1 when the headers are on the top of the board.

The EZRS232 interface board is connected to the carrier by slipping the female header over the programming leads. These are the first five leads on the right side of the carrier as shown in Figure 21. You can now connect the PC to the indoor satellite and apply power.

If you have not already done so, download and install the free Dios Compiler from the Kronos Robotics website. You can pick up a copy at **www.kronosrobotics.com/downloads/DiosSetup.exe**.

Once installed, start the program and load the code from Program 1 into the compiler and hit the program button. The compiler should compile the program, then upload the code to your DiosPro chip. Once done, the status LED will blink and the word "test" will continue to print on the debug terminal of the program.

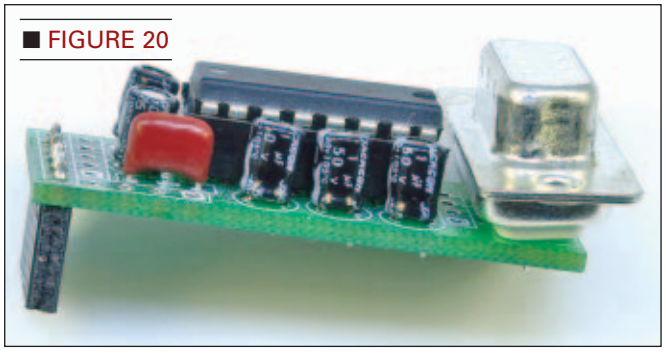
Back in March, I showed you how to build the 1Wire temperature sensor shown in Figure 22. Information for this sensor is also available on the Kronos Robotics website.

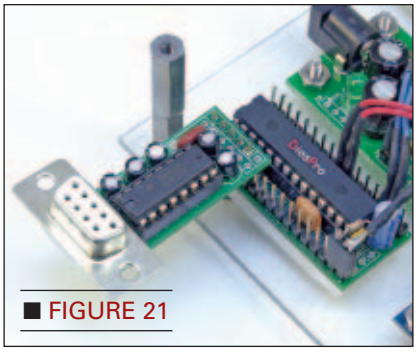
You will need one of these remote sensors connected to your indoor satellite. Once built, just plug the connector into one of the existing sensors mounted on the satellite.

PROGRAM 1

```
DiosPro
'LED Test Program for Indoor Weather
' Satellite module
func main()

 gconst STATLED 1
 output 0,STATLED
 low STATLED,0

Loop:
 print "Test"
 high STATLED
 pause 200
 low STATLED
 pause 200
 goto Loop

endfunc
```

■ FIGURE 20





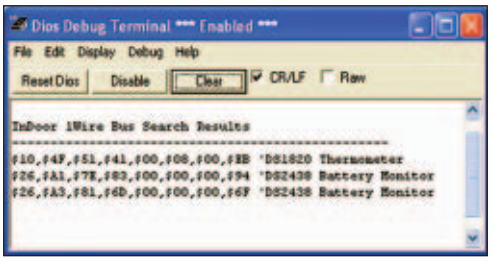
■ FIGURE 21

Performing a Network Search

In order to read

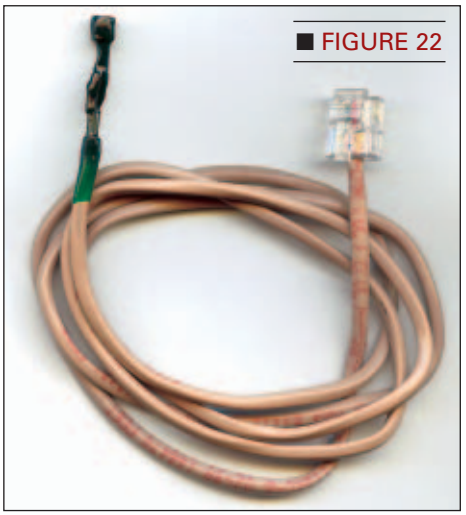
the 1Wire sensors, you will need to obtain the ROM serial numbers from each of the sensors on the network. Included with the downloads for this project is a program called Networksearch.txt. With the temperature sensor connected to your satellite, load and run the Networksearch.txt program. If your sensors are connected properly, the data from the three sensors should be displayed as shown in Figure 23.

■ FIGURE 23



Unfortunately, both the humidity sensor and the pressure sensor use the same 1Wire interface chips so it is up to you to determine which ROM number is associated with which sensor. To do this, you can temporarily disconnect the humidity sensor and run the search program.

■ FIGURE 22



PARTS LIST

The following is a breakdown of the sources for all the components needed for Parts 2 and 3 of this project.

MAXSTREAM

❑ Starter Kit #XB24-DKS
http://store.maxstream.net/index.cfm?fuseaction=product.display&Product_ID=1

❑ Also available from Mouser at:
www.mouser.com/search/ProductDetail.aspx?R=XB24-DKSvirtualkey61440000virtualkey888-XB24-DKS

Or do a search for XB24-DKS

JAMECO ELECTRONICS

❑ Standoffs
www.jameco.com/webapp/wcs/stores/servlet/CategoryDisplay?storeId=10001&catalogId=10001&langId=-1&categoryId=355050

KRONOS ROBOTICS

❑ DiosPro 28 Chip
www.kronosrobotics.com/xcart/customer/product.php?productid=16429

❑ Dios Carrier 1
www.kronosrobotics.com/xcart/customer/product.php?productid=16170

❑ 3.3V to 5V Interface Kit
www.kronosrobotics.com/xcart/customer/product.php?productid=16537

❑ 40-Pin Male Header
www.kronosrobotics.com/xcart/customer/product.php?productid=16290

❑ T220 Heatsink
www.kronosrobotics.com/xcart/customer/product.php?productid=16250

❑ 1K Resistors
www.kronosrobotics.com/xcart/customer/product.php?productid=16178

❑ Regulator Kit
www.kronosrobotics.com/xcart/customer/product.php?productid=16304

❑ 5V Regulator Chip (to be used in outdoor satellite)
http://www.kronosrobotics.com/xcart/customer/product.php?productid=16208

❑ 100 µF Capacitors
www.kronosrobotics.com/xcart/customer/product.php?productid=16202

❑ .1 µF Capacitors
www.kronosrobotics.com/xcart/customer/product.php?productid=16198

❑ 14V DC Adapter
www.kronosrobotics.com/xcart/customer/product.php?productid=16500

❑ Free Dios Compiler (Includes 1-Wire libraries)
www.kronosrobotics.com/downloads/DiosSetup.exe

SCHMARTBOARD

❑ Prototyping Board (.1")
www.schmartboard.com/index.asp?a=11&id=24

❑ Jumpers 5" Yellow
www.schmartboard.com/index.asp?a=11&id=42

❑ Jumpers 3" Red
www.schmartboard.com/index.asp?a=11&id=41

SPARK FUN ELECTRONICS

❑ SCP1000
www.sparkfun.com/commerce/product_info.php?products_id=8161

❑ XBee Breakout Board (used to build various interface boards)
www.sparkfun.com/commerce/product_info.php?products_id=8276

❑ 2 mm Connectors (you need two for each breakout board)
www.sparkfun.com/commerce/product_info.php?products_id=8272

HOBBY BOARDS

❑ Barometer Module (B1-R1-A)
www.hobby-boards.com/catalog/product_info.php?cPath=22&products_id=36

❑ Humidity Module (H3-R1-A)
www.hobby-boards.com/catalog/product_info.php?cPath=22&products_id=46

LOCAL HARDWARE OR HOME CENTER

❑ Double Sided Tape
❑ PlexiGlas (or equivalent)

To test the sensors, run the program called SensorTest.txt. This program will take readings from the temperature sensor, barometric sensor and the humidity sensor and display them on the debug terminal. At the very beginning of the program are three entries that assign the ROM addresses for the sensors. You will need to change these entries to match your own sensors.

The sensor data will also be sent over the network via the XBee module. If you connect your PC to one of your development boards and run the X-CTU software in terminal mode, you should be able to see the network data.

Final Thoughts

I wanted to get into the protocol I developed for this project but just did not have the space to do it this month. So it will have to wait until the end of the series, which is where it is needed anyway.

We used the Hobby Board 1Wire pressure sensor in this project. It has a built-in thermometer, but due to the heat generated by the sensor, this thermometer may be a bit unreliable. This also applies to the humidity sensor. On the other hand, you could have used the SparkFun pressure sensor that I presented last month in the barometer plotter. This sensor has both a reliable pressure sensor and a temperature gauge so the need for an external sensor is not required. The use of an indoor humidity sensor is really not required. I like to have one because I do a lot of work with wood, and I like to know what the humidity is in my lab/shop area.

What's Next

Stay tuned because next month, we will build the Outdoor Weather Satellite. Again, we will be using a Maxstream XBee module, as well as a DiosPro 28 to interface with the various sensors.

Be sure to check for updates at **www.kronosrobotics.com/Projects/wirelessweather.shtml**. **NV**

Links

- *Hobby Boards*
  www.hobby-boards.com
- *Spark Fun Electronics*
  www.sparkfun.com
- *Kronos Robotics*
  www.kronosrobotics.com/xcart/customer/home.php
- *SchmartBoard*
  www.schmartboard.com/index.asp?a=11&page=a_products
- *Jameco Electronics*
  www.jameco.com

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Fairchild Semiconductor	Infineon Technologies	Fairchild Semiconductor	Cypress
Freescale Semiconductor	Integrated Devices	Freescale Semiconductor	Diodes INC.
Intersil	Intel Corporation	Integrated Devices	Fairchild Semiconductor
Lattice Semiconductor	Intersil	Intel Corporation	Freescale Semiconductor
Lite-On Semiconductor	Lattice Semiconductor	Intersil	Infineon Technologies
NEC	Maxim	Lattice Semiconductor	Integrated Devices
Sharp Microelectronics	National Semiconductor	Maxim	Intel Corporation
ST Microelectronics	NXP (formerly Philips)	National Semiconductor	Intersil
Texas Instruments	ST Microelectronics	ST Microelectronics	Lattice Semiconductor
	Texas Instruments	Texas Instruments	Linear Technologies
			Lite-On Semiconductor
			Maxim
			Micron Technologies
			Microsemi
			National Semiconductor
			NEC
			NXP (formerly Philips)
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These simple-to-build tilt light projects were designed to please different members of the family.

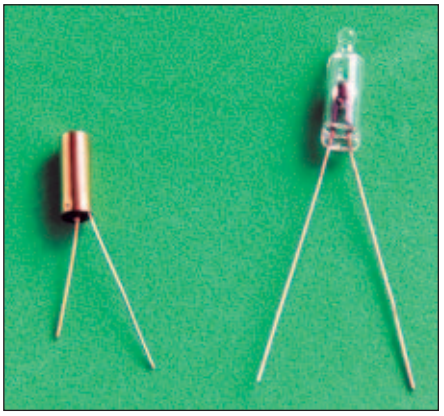
TILT LIGHTS

Show off your electronic prowess with these customized lights.

There's a tilt flashlight for mom, a tilt emergency light for dad, a tilt curio box light for a little girl, and a tilt dump truck light for a little boy.

Keep 'em on the kitchen counter, on your desk, or by your bedside — these little light units stay 'off' in the upright position and turn 'on' when laid flat or when a lid is lifted. They are great as emergency lighting or flashlights. For kids, they are reassuring devices that — when kept nearby — can be turned on for occasional monster checks.

All four units described here are made from only five components (battery, battery holder, LED cluster, tilt switch, and project box or other container) and are very easy to construct. The LED clusters are all available from **www.elec-goldmine.com** in a variety of colors and formats (see Table 1). The tilt switches can be found from a number of vendors; the ones used for these projects (see Figure 1) consist of two types: a mercury tilt switch (part # 1700 TLMC) and a rollerball tilt switch (part # 1700 TLRB) available from **www.elecxpress.com**. Figure 2 shows the basic wired components (LED cluster, tilt switch, and batteries) in several on and off configurations. A small button was cemented to the top of the project case to indicate off when the button is up. All components — with the



■ FIGURE 1. Rollerball tilt switch (left) and mercury tilt switch (right) available from Electronix Express. The body of each unit is about one half inch in length.

■ FIGURE 2. Basic wiring with different on and off postions.

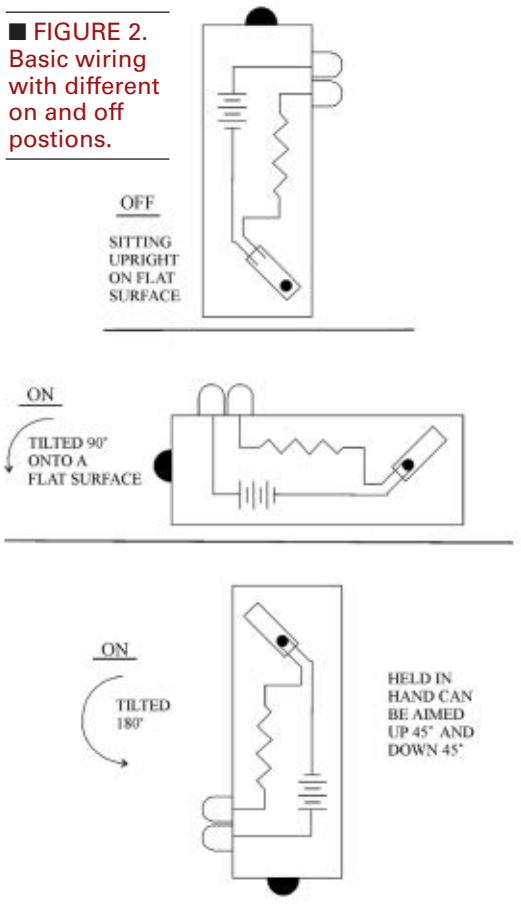
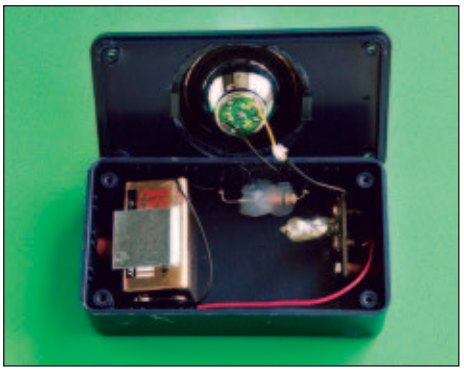


Table 1. LED Clusters

Description	Operating Voltage	Catalog #
• 3 LED White Cluster and Reflector	4.8 VDC-6.0 VDC	G15654
• Brilliant White 4 LED Cluster	3.0 VDC-3.8 VDC	G14877
• Blinding Blue 3 LED Cluster	9.0 VDC-14.0 VDC	G15261
• Blinding Yellow 3 LED Cluster	9.0 VDC-12.0 VDC	G15605

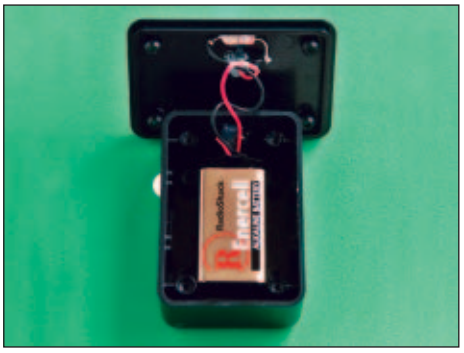
■ FIGURE 3. Tilt light flashlight.



■ FIGURE 4. Innards of flashlight.

■ FIGURE 5. Tilt light flashlight rotated 180 degrees to on position.

■ FIGURE 6. Compact emergency tilt light.



■ FIGURE 7. Innards of emergency tilt light.

■ FIGURE 8. Compact emergency tilt light in on position.

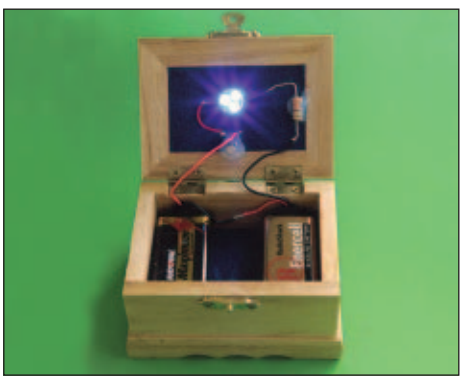
exception of the battery holder(s) — were anchored using hot melt glue.

A tilt light flashlight constructed from the three white LED cluster attached to a 4″ x 2″ x 1-1/4″ project box is shown in Figure 3. A one watt, 33 ohm dropping resistor was used with a nine volt battery to provide the power supply (Figure 4). This unit can be used like a conventional flashlight by rotating the project box 180 degrees (Figure 5) to turn it on and then tilting the box up and down 45 degrees for sweeping an area without shutting it off. A smaller version of this unit (utilizing a project box 3″ x 2″ x 1-1/8″) without a reflector is shown in Figure 6. The four white LED cluster was glued to the outside of the box and powered by a nine volt battery wired in series with a one watt, 270 ohm dropping resistor (Figure 7) and creates a ton of illumination when used as a compact emergency light (Figure 8).

Figure 9 is a photo of a curio box used to make a tilt light by wiring the LEDs and the switch into the lid so that it turns on when opened. The blue three LED cluster was coupled to two nine volt batteries wired in series, using a one watt, 330 ohm dropping resistor to provide the light source

■ FIGURE 9. Wood curio box used to make tilt light.

■ FIGURE 10. Interior of curio box with lid open and turned on.



■ FIGURE 11. Dump truck tilt light.

(Figure 10). A John Deere dump truck (RC2 Brands, Inc., Stock Number 35322 found in Wal-Mart) provided the vehicle (pun intended!) for the construction of the tilt light shown in Figure 11. The yellow three LED cluster wired directly to a nine volt battery turns on when the dump is raised (Figure 12).

The neat thing about these lights is that the user doesn't have to fumble for a switch, and if the batteries are fresh, it should be obvious when the lights are on or off. The main problem with these lights is that if you use them as a gift, you need to place them carefully somewhere so that they remain off and don't drain the batteries. **NV**

■ FIGURE 12. Truck tilt light with raised dump in the on position.

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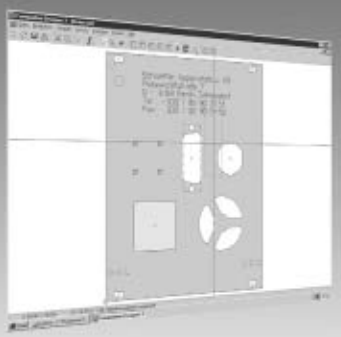

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BINGO
PLAYING WITH PICS

This project was inspired when I was playing BINGO with my friends. Somehow during play, the numbers that were called got mixed up, and there was confusion as to whether or not one of the players had actually won the game.

It seemed to me that having a microcontroller select and verify the numbers would be much more reliable.

The game of BINGO is quite simple: any number from 1 to 75 is picked and called out to the players. Numbers may not be called more than once during any game. Once a player has selected all the numbers in a row (vertical, horizontal, or diagonal), he yells out "BINGO" and wins the game.

A program for BINGO must be able to randomly pick any number from 1 to 75, and display it as it should be called, i.e., "B17" or "N39." The program must keep track of which numbers have been used and prevent them from being displayed again in the same game. The displayed numbers must then be available for verification once a player has called BINGO. (See the sidebar for more details about the game).

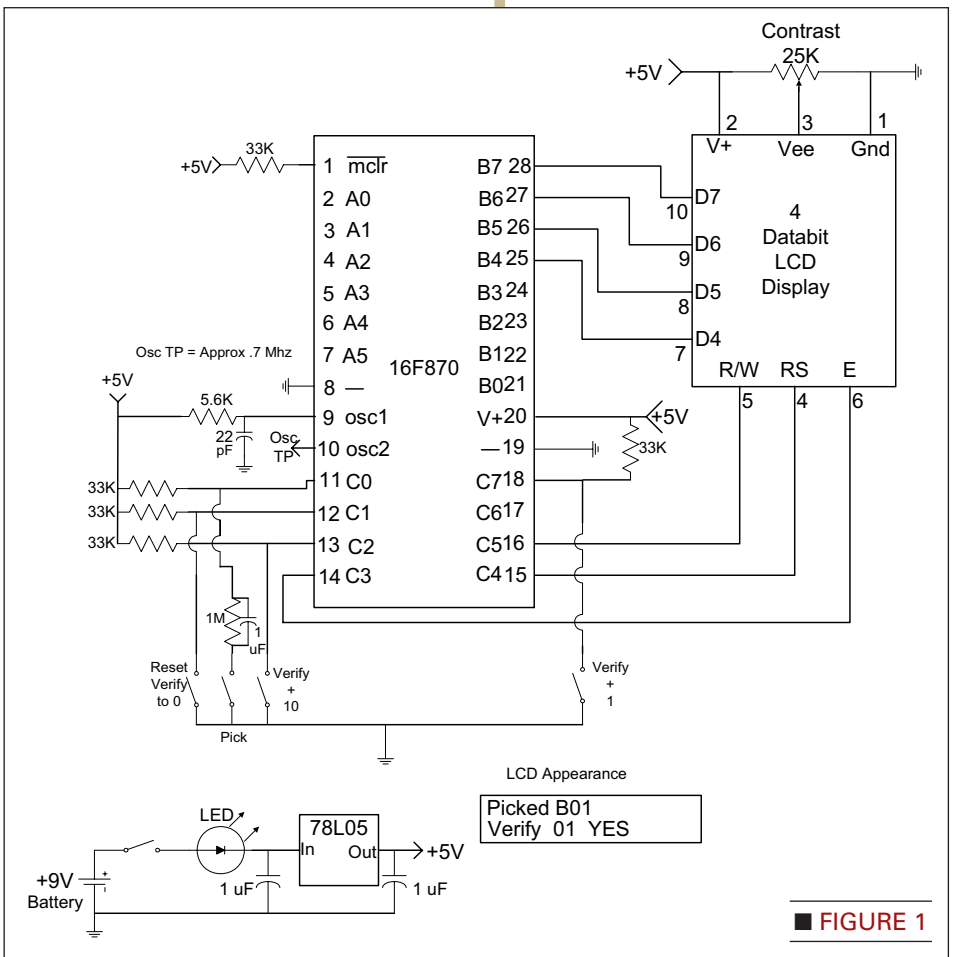


FIGURE 1

The Hardware

I have used the PIC16F870 in previous projects and find it extremely versatile and well behaved. A different PIC could have been used in the project (for example, a 16F84A), but since I had several 16F870s on hand from previous projects, I decided to use it.

The program presented here can easily be modified to use almost any PIC that has at least 11 general-purpose I/O lines to control the LCD and accommodate the push button switches. This project uses a standard four data bit LCD display with the Hitachi HD44780 controller. However, any other LCD using the HD44780 controller could also be used. Add a few push-button switches, some resistors, a few capacitors, and presto! You have BINGO on a PIC. The schematic is shown in Figure 1.

The Programming

The heart of this project is in the programming. To me, PIC programming is a very interesting subject, and there are many PC-based software programs to choose from. Many purists will tell you the best way to write programs for PICs (but not the easiest) is using the 35 assembly

language instructions outlined in all the PIC data sheets. After trying that and having a hard time doing all the intricate manipulation of bits and bytes and the associated "housekeeping," I needed an easier solution.

I finally decided on microEngineering Labs' PICBASIC PRO software with the additional Microcode Studio Plus GUI software (both are available at **www.melabs.com**). You could use the PICBASIC software with this project, but it does not have all the commands available with PICBASIC PRO.

The commands and instructions in the software are intuitive and easy to follow; the programs are easy to construct and work with little or no tweaking. The actual PICBASIC PRO *.bas file needed is included in the BINGO.zip file on the *Nuts & Volts* website (**www.nutsvolts.com**), along with all the other necessary files. The *.asm file and associated files necessary to use the MPLAB IDE program (free from **www.microchip.com**) to modify or change the BINGO program and re-compile it are also provided. The MPLAB IDE program produces a *.hex file which can be used to program the PIC16F870.

As we go through the following steps, please refer to Figures 2 and 3 of the BINGO program block diagram.

1) The program begins by setting up the necessary ports to control the LCD display.

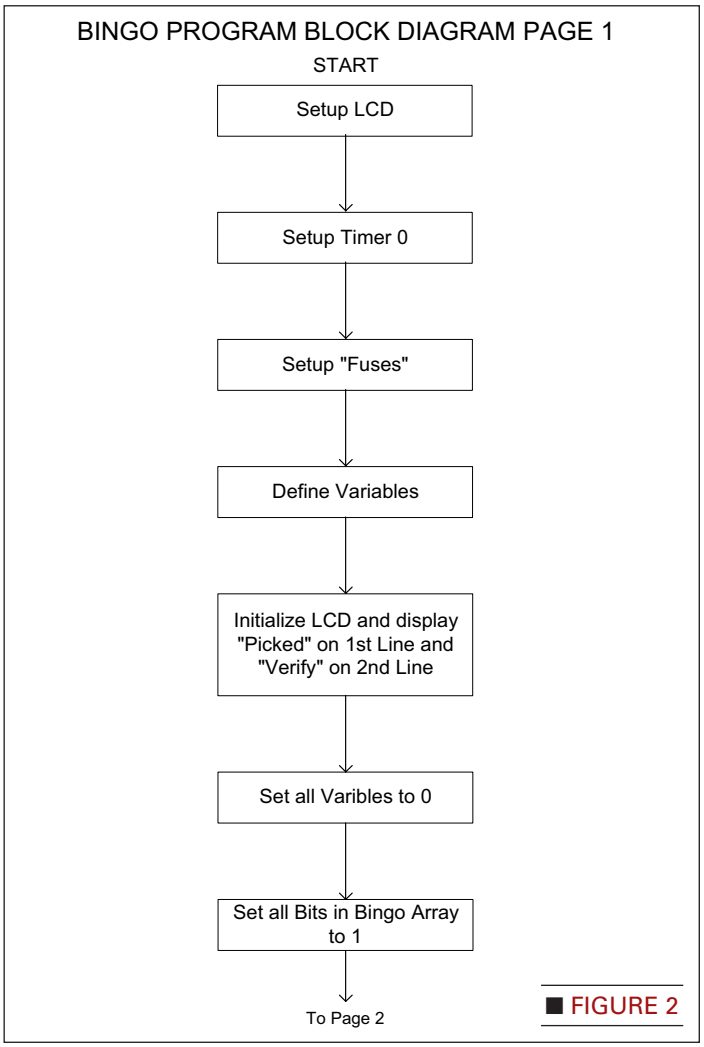
```
'LCD Defines
DEFINE LCD_DREG   PORTB          'Set LCD Data Port
DEFINE LCD_DBIT   4              'Set Start Bit
DEFINE LCD_EREG   PORTC          'Set LCD Enable Port

etc.
```

2) Timer0 is then set up to run from the PIC clock divided by 256. After trying several different prescaler values, I found it gave the most random selection of Bingo numbers. Timer0 runs constantly and cannot be stopped and started.

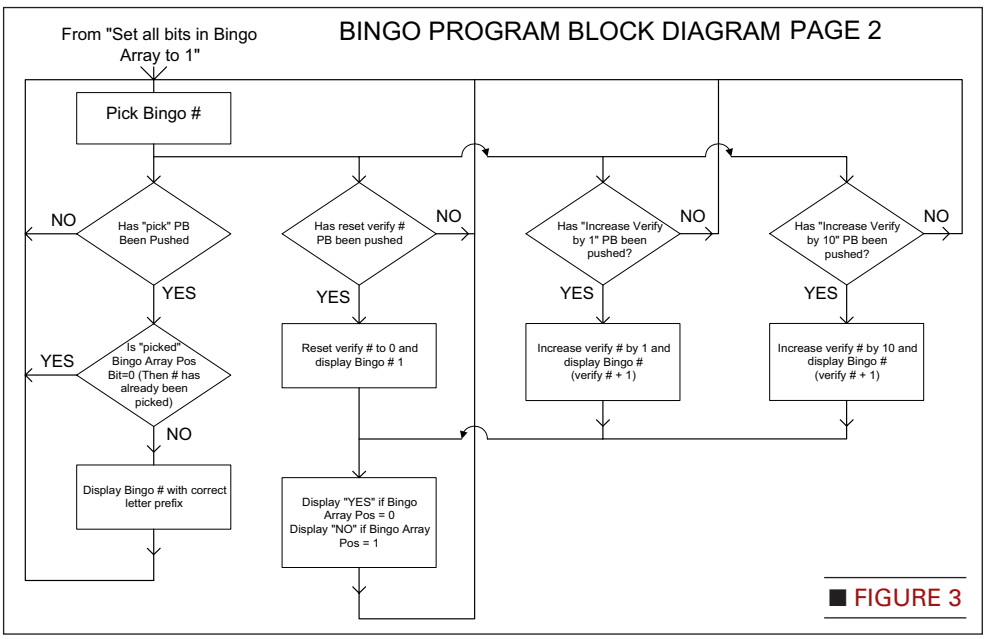
PICBASIC PRO makes it easy to set up Timer0. The purpose of each bit in the control word for the Option Register (which controls Timer0) is outlined in the PIC 16F870/871 data sheet (available on the *Nuts & Volts* website). A command in the program simply equates the OPTION_REG to the necessary control word on Line 49 of the program:

```
OPTION_REG = %10000111   'TMR0 =
1:256
```

3) The next step is to set the PIC "fuses." In PIC language, these are actual configuration parameters of the PIC and must be done using an assembly language command



■ FIGURE 2



■ FIGURE 3

because there are no corresponding PICBASIC PRO commands. To be exact, the following parameters are set by the assembly language command in Line 52:

```
@ __config _RC_OSC & _WDT_OFF & _PWRTE_ON &
          _LVP_OFF & _CP_OFF
```

A) _config instructs the PIC the items in the line will be configuration commands.

B) RC_OSC tells the PIC a resistor-capacitor combination will be used to run the PIC clock. (If desired, a crystal can be used for PIC oscillators to reduce cost.)

C) WDT_OFF tells the PIC to turn off the watchdog timer. The watchdog is used to "wake up" the PIC after a sleep command has been received and the timer has expired. It is not used in this program.

D) PWRTE_ON tells the PIC to turn on the power-up Ttimer. This timer keeps the PIC in reset mode for 72 milliseconds after power is applied so the program won't begin to run until the power is stable.

E) LVP_OFF tells the PIC to turn off the low voltage programming option. It is not used in this program, but could be.

F) CP_OFF tells the PIC to disable the code protection in the device. If this feature is turned on, new code cannot be programmed into the PIC nor can anyone read the code that is in the PIC. Obviously, this feature is not used in this program.

■ FIGURE 4

B	I	N	G	O	B	I	N	G	O
1 to 15	16 to 30	31 to 45	46 to 60	61 to 75	1 to 15	16 to 30	31 to 45	46 to 60	61 to 75
11	21	34	55	61	4	17	45	50	70
5	23	31	52	68	14	19	35	58	73
13	17	FREE	54	65	2	26	FREE	60	68
7	27	42	57	72	10	17	41	47	77
14	28	37	56	64	6	21	42	59	69

B	I	N	G	O	B	I	N	G	O
1 to 15	16 to 30	31 to 45	46 to 60	61 to 75	1 to 15	16 to 30	31 to 45	46 to 60	61 to 75
4	21	39	47	73	7	16	42	58	73
8	30	40	53	61	2	30	34	51	70
12	18	FREE	58	71	14	26	FREE	52	62
5	22	32	54	74	4	27	43	48	64
4	29	45	56	73	3	22	44	60	68

B	I	N	G	O	B	I	N	G	O
1 to 15	16 to 30	31 to 45	46 to 60	61 to 75	1 to 15	16 to 30	31 to 45	46 to 60	61 to 75
12	28	44	56	63	9	28	45	56	61
11	17	39	54	66	4	22	38	48	72
8	22	FREE	49	75	14	20	FREE	51	71
1	16	31	47	70	13	25	44	53	72
6	19	40	57	73	8	21	36	55	63

4) The next step is to define all the variables in the program. The most important one is the BINGO array. This is the main part of the program. An array in PIC language is simply a number of variables with the same name, but different sequential locations in the program. The PIC is limited to the number of variables that may be used, and that limitation is in direct correlation with the number of bits each of those variables use. For example, the PIC we're using allows up to 256 variables with one bit; 96 variables with one nibble (four bits); and only 48 variables with one byte. For BINGO, the numbers we need (1 to 75) cannot be accommodated by the above variable limitation of the PIC. However, if we use the variable ADDRESS as the BINGO number, then 74 times one bit variables may easily be defined and used. As an added bonus, the bit in each variable may be used to determine if that variable has been used or not. That gives us a way to both insure BINGO numbers are not "called" twice and verify which numbers were displayed. The remaining variables are INDEX, POINTER, VERIFY, and PICKED. Please refer to lines 55 through 62 for their use.

```
BINGO       VAR bit [75]     'Place holder for Bingo
                             'Number Pointers
INDEX       VAR byte         'Used to set all bingo
                             'array bits to 1
POINTER     VAR byte         'pointer number
VERIFY      VAR byte         'picked number to be
                             'verified at end of
                             'game, always 1 less
                             'than the actual bingo
                             'number. Array starts at
                             '0 but bingo number
                             'starts at 1
PICKED      VAR byte         'final picked number for
                             'playing bingo, no
                             'repetitions
```

5) The next piece of the program clears the LCD display, puts the cursor at the first position of the first line, and then displays "Picked" on the first line and "Verify" on the second line. This is done in lines 65 through 68.

```
LCDOUT $FE, 1                'Clear LCD
LCDOUT $FE, 2                'LCD Cursor to 1st
                             'Position, 1st Line
LCDOUT "Picked "             'Display "Picked"
LCDOUT $FE, $C0, "Verify "   'Display "Verify"
```

6) All the variables are set to 0.

7) All of the bits in all the BINGO variables (there are 75 of them addressed from 0 to 74) are set to 1. This gives a starting point where none of the numbers have been picked (as their values are 1).

8) Lines 82 and 83 of the program limit the Timer0 value between 0 and 74 and make the "pointer" variable equal to whatever value Timer0 is at that point. The pointer plus 1 will be our BINGO number.

```
IF TMR0 => 75 THEN TMR0 = 0                    '
pointer = TMR0
```

9) The next actions of the program depend solely on which buttons are pushed.

A) If the Pick button is pushed, the value of the pointer is used to reference that location of the BINGO array. If the value of that variable is 0, that means the number has already been used and the program loops back to step 7 discussed previously. If the value is 1, that means the number has not been picked and the program displays the number on the LCD with the correct BINGO letter in front of it (Lines 93 through 99 of the program). The program then goes back to the Pick location (Line 81).

B) If the Reset Verify pushbutton is selected, the verify number is reset to 0 and the BINGO number displayed is 01. In addition, the program checks this array location and displays a YES if the location contains 0 or a NO if the location contains 1 (Lines 120 through 131). After this, the program goes back to the Pick location (Line 81).

C) If the Increase Verify by 1 button is pushed, the verify number is increased by 1 and this number plus 1 is displayed as the verified BINGO number. Now the program jumps back to the YES and NO checking routine and then returns to the Pick location (Line 81).

D) If Increase Verify by 10 button is pushed, the verify number is increased by 10 and this number plus 1 is displayed as the verified BINGO number. Again, the program jumps back to the YES and NO checking routine and returns to Line 81.

When the Bingo unit is first turned on, the display appears as follows:

Picked
Verify

When the first number is picked, the display then shows:

Picked N44
Verify

When one of the Verify buttons is pushed, the display appears as one of the following options:

Picked N44 Picked N44
Verify 44 YES *or* Verify 01 NO

The use of the unit is really quite simple. The caller pushes the Pick button every time he needs to call a new number. When someone yells out BINGO, the caller first pushes the Reset Verify Number button and then can increase that number by either 1 or 10. A YES verifies the number; a NO means that number has not been picked, so the caller can go back to Picking numbers until the next BINGO is called. Since the Verify number cannot be decreased, a bit of manipulation is required to go back to a lower number than the one last verified. A Verify Number reset is required; increments of 1 or 10 to get to the next number will enable the verification.

BINGO Cards

The final requirement to play BINGO is having the proper playing cards for the game. I found a solution for this by using a Microsoft Excel spreadsheet. Figure 4 is a graphical representation of this. (The actual Excel spreadsheet is included with the files on the *Nuts & Volts* website.) As you can see, there are six cards on the spreadsheet which may

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❑ 1	R7	1M ohm resistor (pkg of 10)	299-1M-RC
10 Turn Trimpot			
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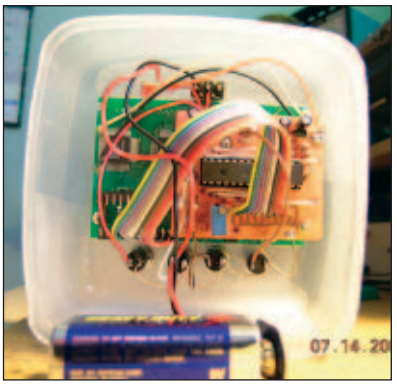
❑ 1		Project box	

*All part numbers listed are from Mouser Electronics (**www.mouser.com**) with the exception of U3.*



■ FIGURE 5

■ FIGURE 6

easily be cut out and used as separate cards. The spreadsheet gets its numbers from an Excel command — RANDBETWEEN(X,Y) — which fills that cell with a random number between the two values, X and Y. You can make the spreadsheet recalculate all the cells and fill them in with new numbers by pressing F9.

The only drawback to the program is it produces duplicate numbers within the columns; i.e., the "B" column could contain any number between 1 and 15, but there is nothing to prevent duplicate numbers in that range. It may be possible to solve this problem using Visual Basic, unfortunately, I am not familiar with this program. I imagine there are *Nuts & Volts* readers who are. To solve the immediate problem, I manually go to any cell with a duplicate number and put in a different one. Not a great solution, but it works.

Construction

Although I have provided a printed circuit board layout with the other project files, I constructed my PCB manually using fingernail polish as an etch resist medium. It works quite well, and it is easy to correct any mistakes prior to etching the PCB. The layout and wiring are not critical, and the project could easily be done on a proto board using point-to-point wiring. Figures 5 and 6 show the completed project. I built my BINGO player inside a Tupperware-type container. It was easy to fabricate and the unit looks quite novel. It runs on a standard nine-volt battery and draws about nine milliamps. The power is routed through an LCD so it is easy to see when the unit is turned on. To start a new game, simply turn the unit off, then on again.

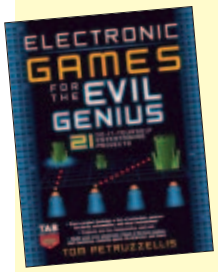
Suggested Improvements

This project could be improved by using a larger LED display that would make its visual presentation much more striking. The programming would have to change to accom-

modate this. Additional circuitry could be installed to add audio.

If anyone is interested, I am willing to modify the program for different types of LCD displays and will email the hex file associated with the new program to you. Email me at chuckirwin43@gmail.com.

I hope this article will encourage readers to find new ways to use microcontrollers. Using PICs and getting them to do what you want is extremely satisfying when the end goal is achieved. **NV**



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The Basics of BINGO

The game of BINGO has been around for many years, and I am quite sure that everyone knows how to play it. With the advent of the *National Bingo* show on TV, the game is gaining a new popularity.

All of the players have at least one (or several) card arranged as shown in Figure A. The numbers are arranged in random order, but not repeated. The "B" column contains five numbers in the range from 1 to 15. The "I" column contains five numbers in the range from 16 to 30. The "N" column contains five numbers in the range from 31 to 45. The "G" column contains five numbers in the range from 46 to 60. Finally, the "O" column contains five numbers in the range from 61 to 75.

The person "calling" the game randomly selects a number between 1 and 75, which he cannot see until he has picked it. He then calls out the number for the players. That number is removed from play and put on a "played list." It cannot be called again during the same game. Once all of the numbers in any horizontal, vertical, or diagonal row on a player's card have been covered, that person then yells out BINGO, and the numbers are then verified by the caller. If everything is correct, the player wins. As each number is called it is eliminated or "covered" on a large sheet used by the caller. That makes it easy to verify the numbers of a winning player.

The game is completely governed by chance. The numbers on the playing cards are random, and the manner in which the numbers are picked is also random. Variations on winning patterns can be used to make the games more challenging. For example, a winning game may be defined as all the numbers being called must form a square on the outside rows/columns of the card.

B	I	N	G	O
1 to 15	16 to 30	31 to 45	46 to 60	61 to 75
11	16	31	55	61
13	24	40	59	63
12	30	FREE	57	67
2	20	39	46	75
9	25	45	50	65

■ FIGURE A

DFT Basics

For some electronics hobbyists, the discrete Fourier transform, or DFT, is a feared and mysterious entity that is best left to the "experts" or those who practice in the field of digital signal processing (DSP) on a daily basis. The truth is, however, that with a little explanation and only a dash of simple math, anyone who can use a spreadsheet or program a microcontroller can understand and put this powerful signal processing technique to work in no time at all.

by Paul Kafig

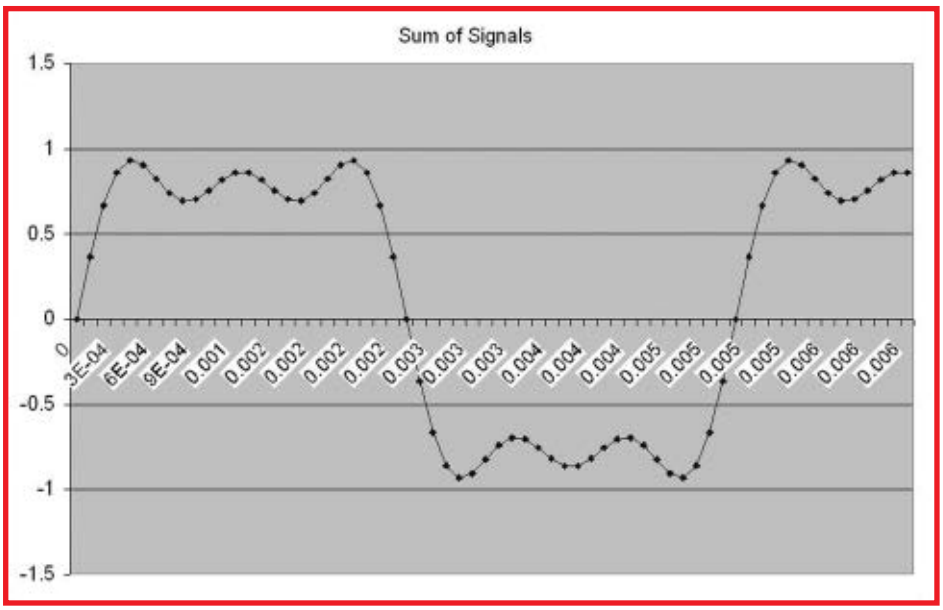


FIGURE 1a. Signal in the time domain. The x-axis is time.

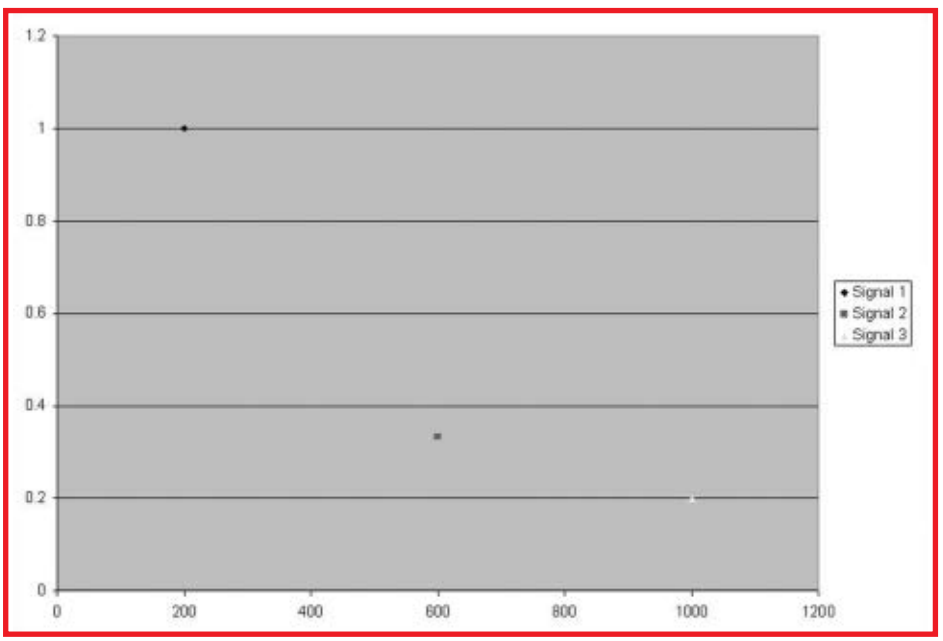


FIGURE 1b. Signal in the frequency domain. The x-axis is frequency.

For those who have never heard of the DFT before, here's a little background. Every signal can be viewed in at least two ways. The most common way is in the time domain. Whenever we look at a signal on an oscilloscope, we're seeing it in the time domain (the x-axis is time). However, we can also view a signal in the frequency domain, so that as we move along the x-axis in the positive direction, we're looking at increasing frequency. The y-axis represents the amplitude of the frequencies. It should be noted that these two domains are like opposite sides of the same coin. One cannot exist without the other, and both are equally valid.

Why bother with the frequency domain? Without going into the mathematics, let's just say that some problems are more easily solved by converting a signal to the frequency domain first, doing some math, and then converting the solution back to the time domain. Examples are readily found in communications where signals are often mixed (heterodyned) and modulated in different ways. Multiplication of sines and cosines can be quite cumbersome in the time domain, but more easily managed in the frequency domain.

Let's look at a sample signal in both domains. If we were to add a 200 Hz sine wave (amplitude 1), a 600 Hz sine wave (amplitude 1/3), and a 1,000 Hz sine wave (amplitude 1/3), we would get the signal in Figure 1a. To most people, it would not be obvious that these three frequencies are present in the figure. However, decomposing the signal in Figure 1a into its frequency components clearly shows which frequencies are present and at what amplitude (Figure 1b).

This example hints at another very important concept: All (reasonably continuous) signals can be made up of a combination of sines and/or cosines. This is Fourier's theorem. You can experiment with this idea using the "Synthesis" tab in the "dft.xls" spreadsheet available on the *Nuts & Volts* website (**www.nutsvolts.com**).

Here's a question for you: If we're given a signal in the time domain, is it possible to represent this signal in the frequency domain? In other words, can we go from something that resembles Figure 1a and determine the same kind of information that's presented in Figure 1b? This answer is — of course — yes. One method of doing this is to use a discrete Fourier transform.

Let's break down this exotic sounding phrase into its basic parts. First of all, a transform is just a word that has to do with taking information in one form and looking at it in another. A simple example is taking Eastern Standard Time and subtracting three hours. If I do this, I've just performed a transform from EST to PST. Fourier (pronounced FOUR-ee-ay) is the name of the French mathematician who contributed greatly to his field. Discrete (as opposed to discreet) means separate. So, instead of working on an analog (or continuous) signal, we're only working with specific (digital or discrete) values of a signal taken at evenly-spaced intervals of time. If we're going to use a

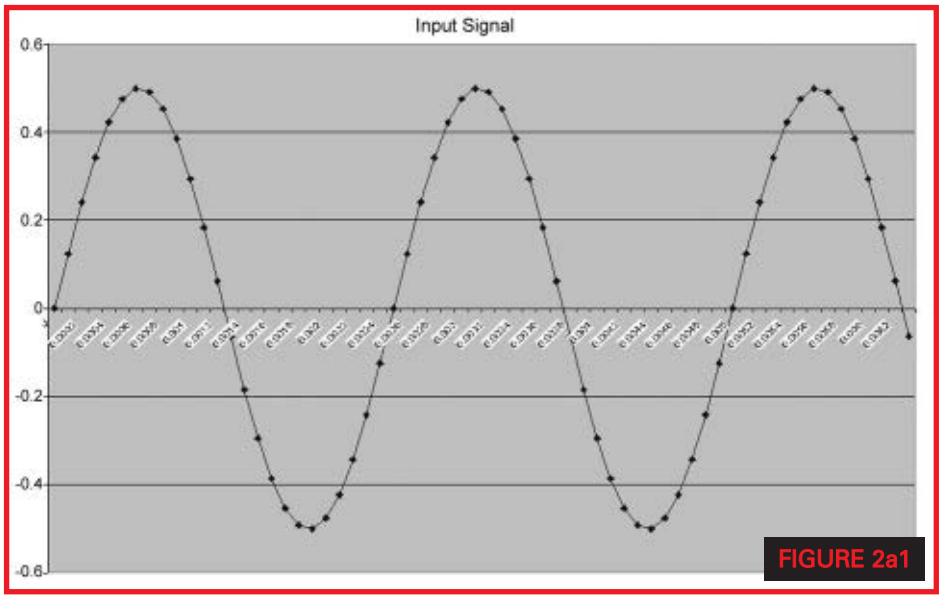


FIGURE 2a1

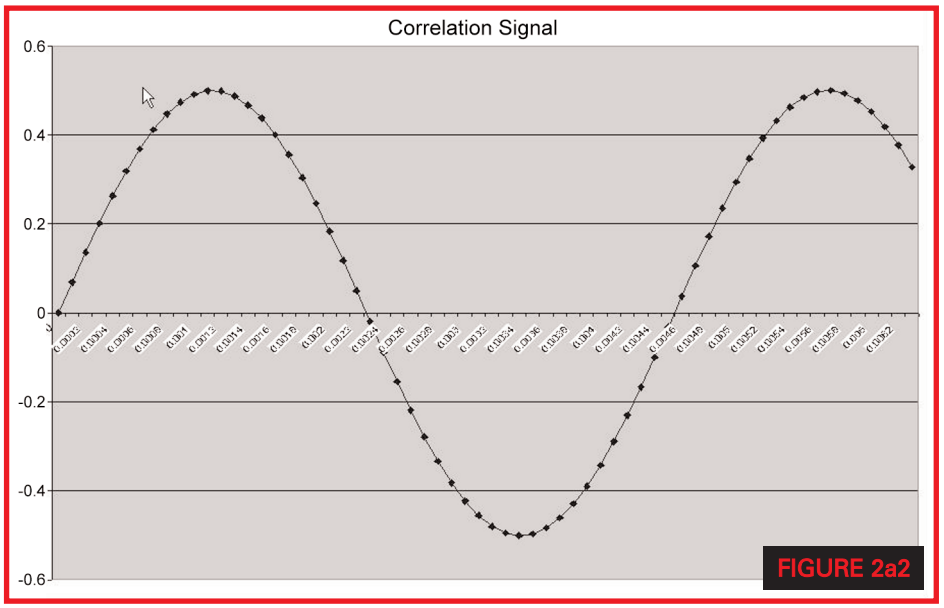


FIGURE 2a2

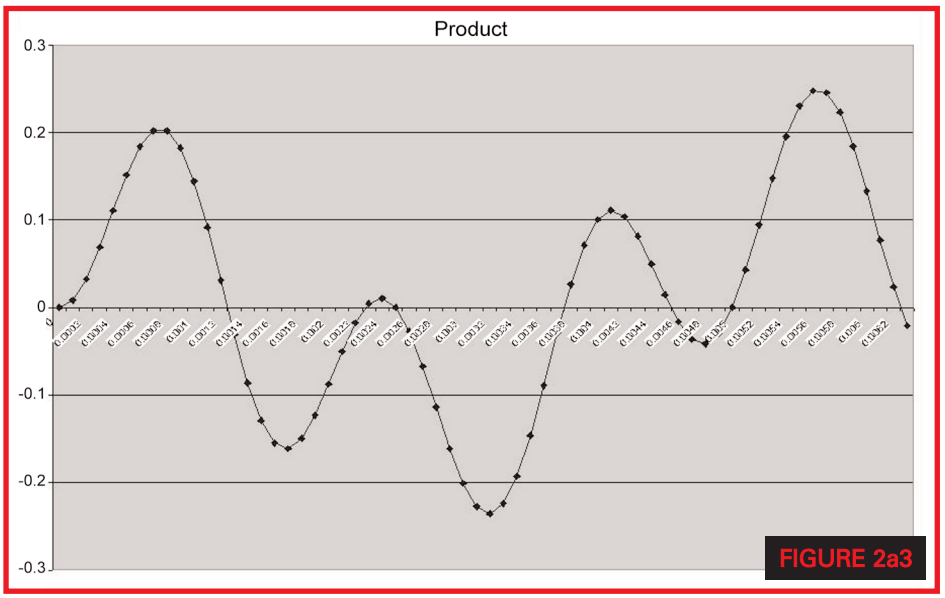


FIGURE 2a3

FIGURE Set 2a. These three graphs show signals with poor correlation.

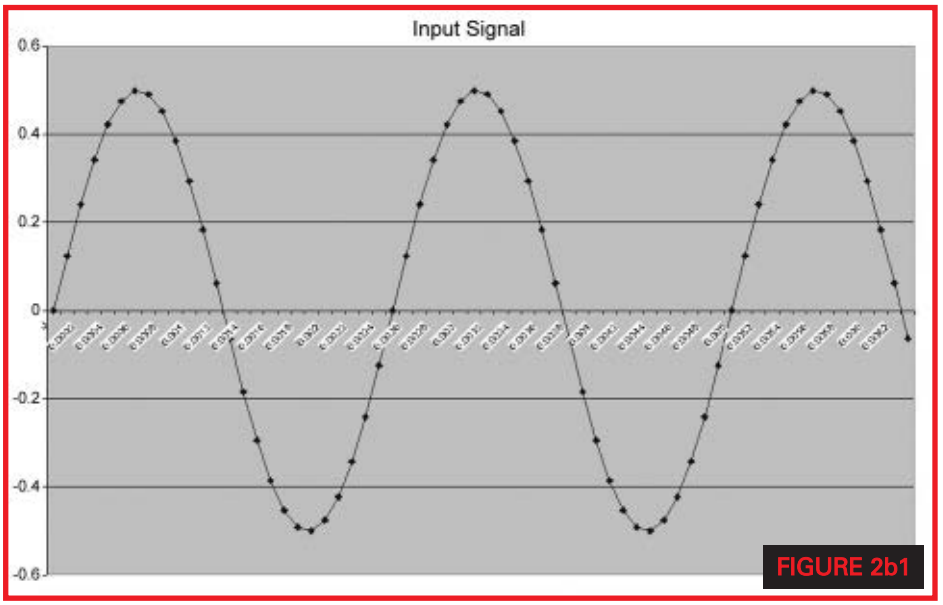


FIGURE 2b1

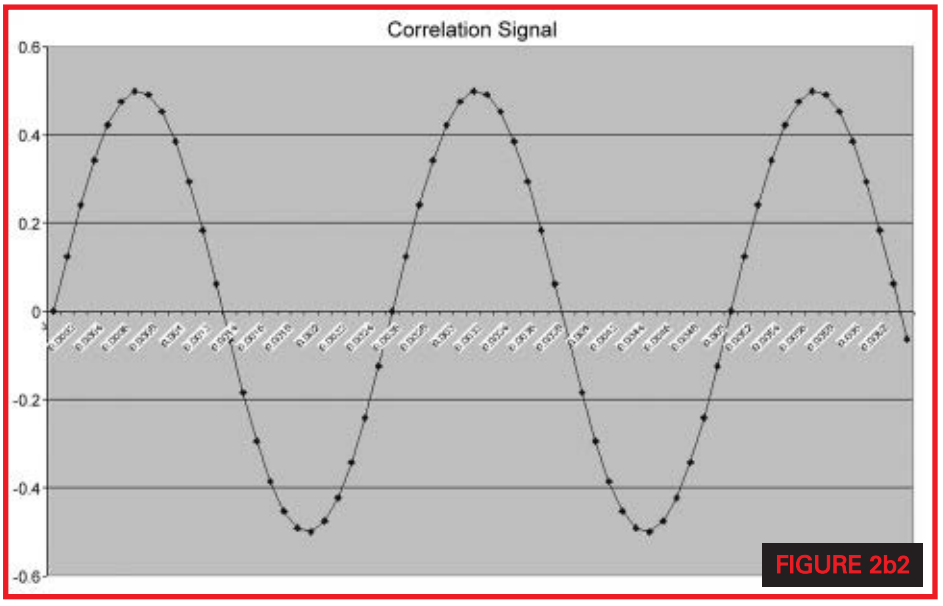


FIGURE 2b2

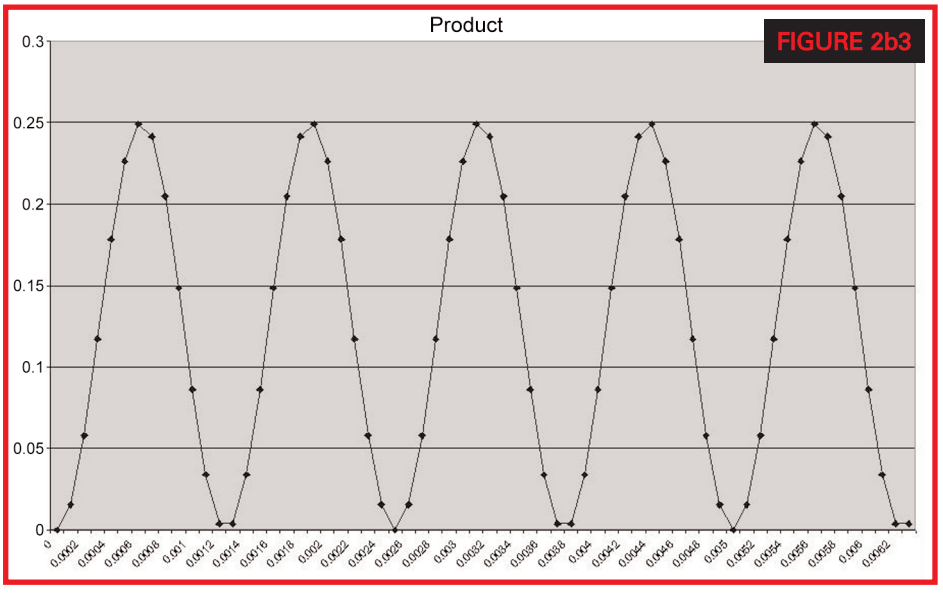


FIGURE 2b3

computer or microcontroller, we have to use a discrete technique.

As you read through this article, be aware that this is not a leisurely read. If this is your first time experimenting with the DFT, you will need to have your sleeves rolled up and your brain focused. Our discussion will be about DFT theory and the Excel spreadsheets that you will be using to experiment with these concepts.

Also keep in mind that my purpose here is to provide only a general introduction to the DFT and to provide the boilerplate tools necessary to launch into an independent detailed study or microcontroller implementation (see suggestions for further reading).

Procedure

First, we'll discuss correlation — the basic building block of the DFT. Then we'll extend correlation to sampled signals, which is necessary for microcontroller and computer applications. Next, a functional DFT program will be demonstrated in Excel with a simple application. Finally, I'll wrap up with a quick overview of aliasing, a nasty phenomenon you'll want to avoid.

Correlation

Loosely speaking, this is a number that represents how well two signals are matched. The higher the correlation (or greater the value), the better they match. Correlation is found by multiplying the respective elements of two sampled signals together and adding each product together. To make this clearer, see Figure sets 2a and 2b.

Figures 2a3 and 2b3 are the products of the other two related signals. They contains points both above and below zero. So in summing the correlation, some points will be added and others subtracted. In Figure set 2b, the input and correlation signals are the same (2a1 and 2a2), so all of the

FIGURE Set 2b. These three graps show signals with excellent correlation.

points in the product signal (2a3) are greater than zero (remember, a negative multiplied times a negative is a positive).

These plots were produced from the "Correlation 1" tab in the Excel spreadsheet. If anything up to this point is unclear, you may want to take a moment and experiment with this worksheet. You can see the cell formulas and change parameters of the test signals. The important concept here is that the closer two signals are to being "the same," the higher the correlation.

Sampled Signals and Basis Functions

Figure 3 shows a signal that is identical to the signal in Figure 2b3. There is one very subtle and important difference in this graph, however. The units for the x-axis are not seconds but rather samples. When a computer or microcontroller takes A/D samples for the DFT, these values will be stored in an array for future processing. In the "Sampled Correlation" tab, there is an added column for sample numbers on the far left. Also in the worksheet is a parameter called "Basis Function." This is a common name for the correlation signal.

The basis number is just the number of cycles of a sine (or cosine) wave that will fit in our sample size. The best way to see this is to put a few different numbers into the basis function cell and see the resulting signal. Figures 4a and 4b show a few examples. While it's possible to put non-integer values into the spreadsheet, the DFT program we will use only uses integer values.

Performing the DFT

Here is where the fun begins (and may get a little complicated, so be patient). In the "DFT" tab, you can modify the test parameters to create a signal with a frequency, amplitude, and (DC) offset of your choosing. Once you've created a signal, press the "Perform Correlation

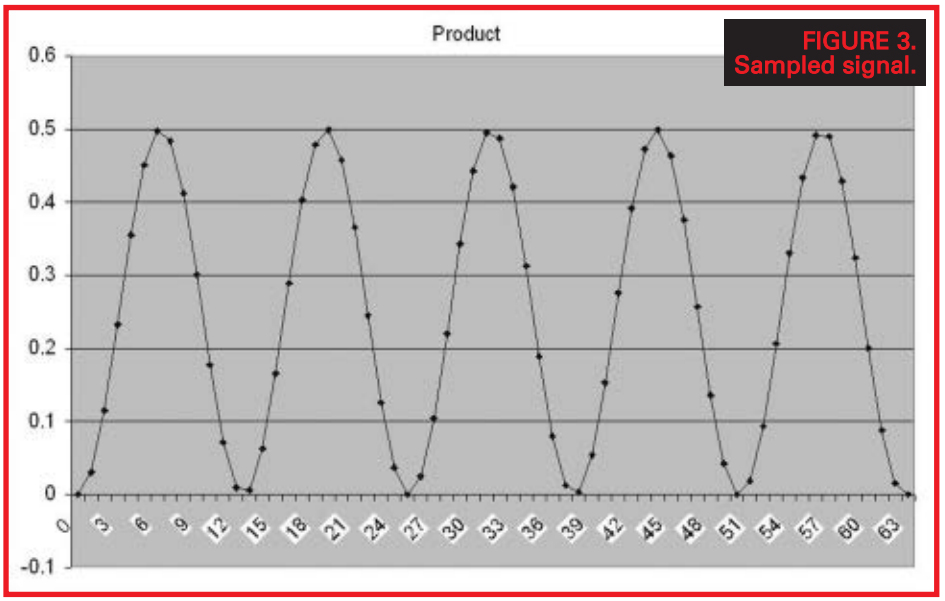


FIGURE 3. Sampled signal.

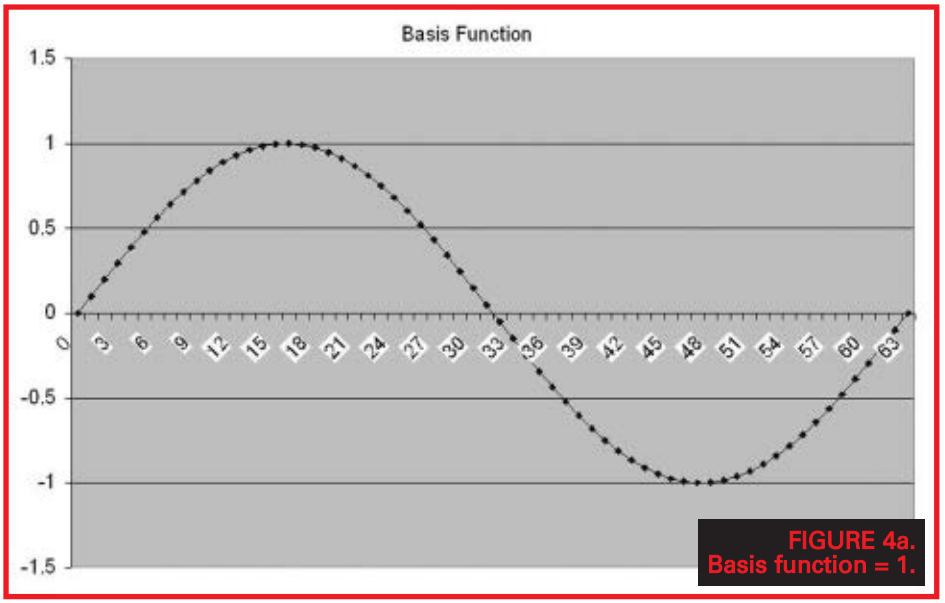


FIGURE 4a. Basis function = 1.

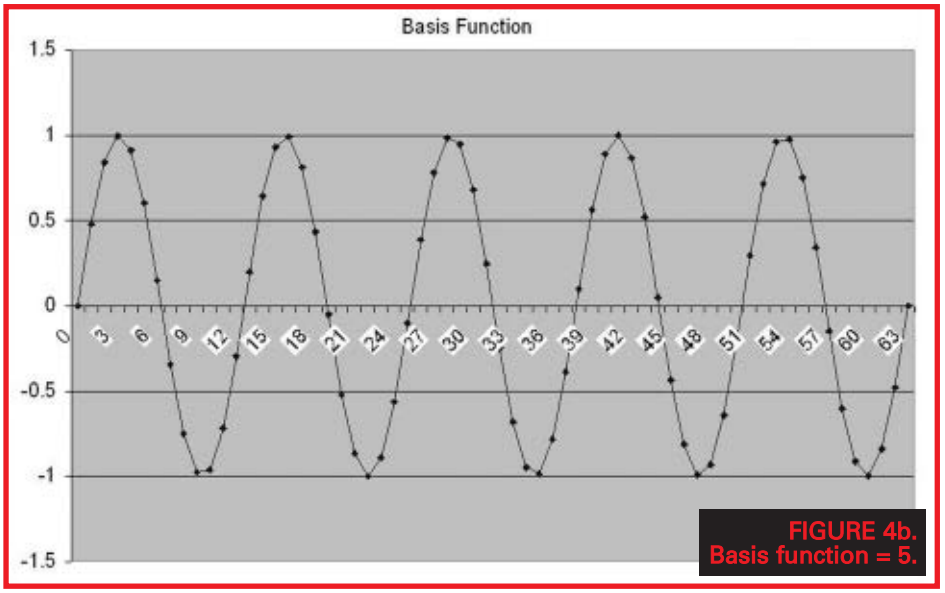


FIGURE 4b. Basis function = 5.

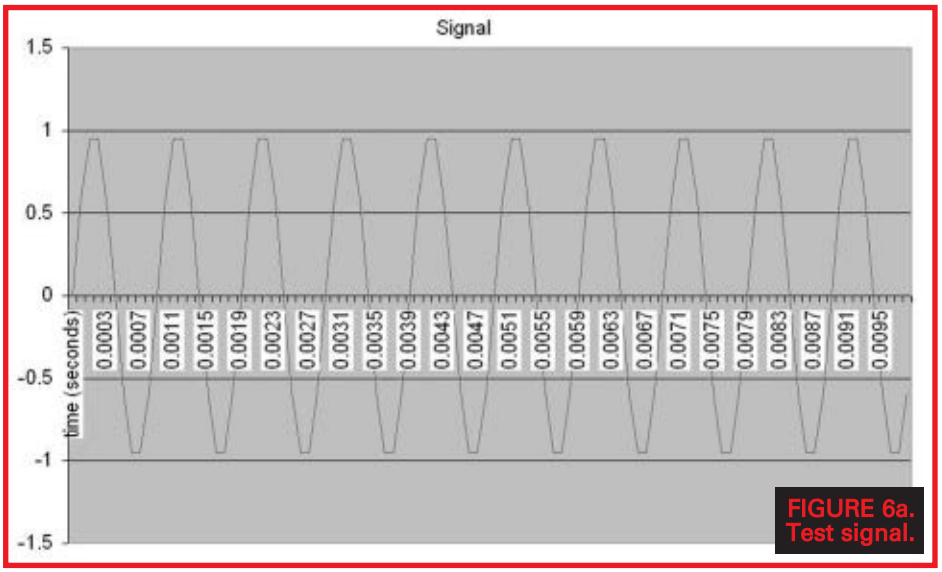


FIGURE 6a. Test signal.

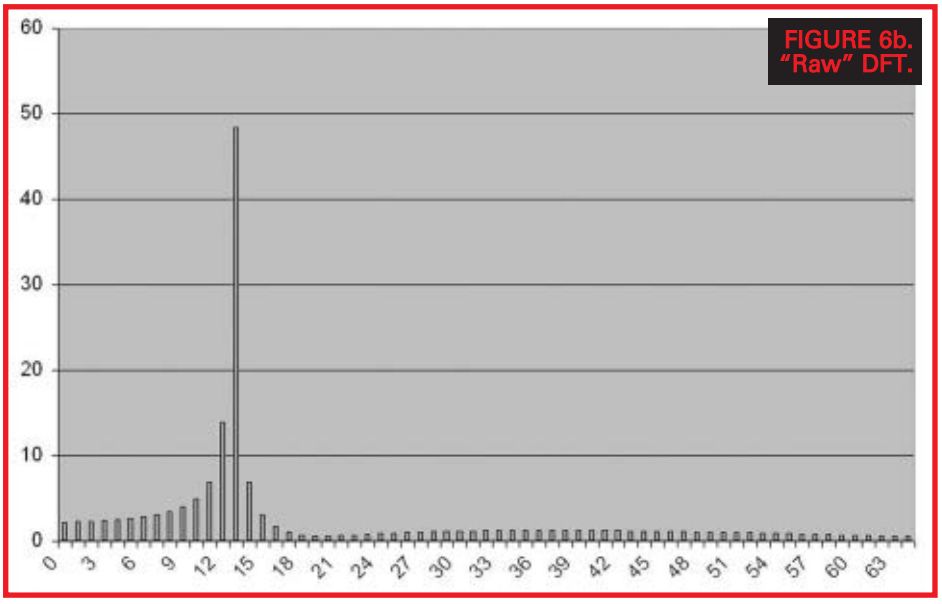


FIGURE 6b. "Raw" DFT.

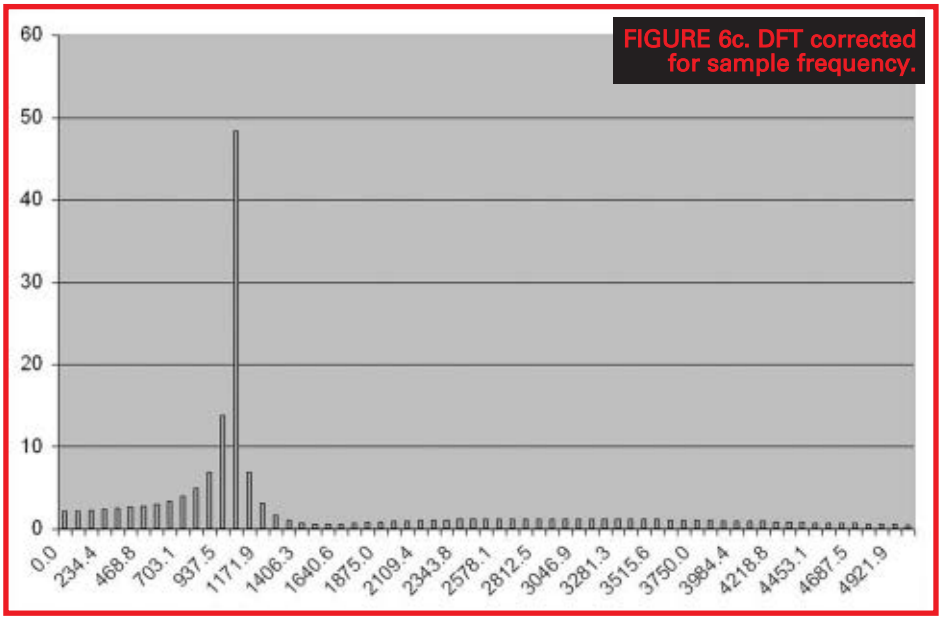


FIGURE 6c. DFT corrected for sample frequency.

FIGURE 5. Entering and exiting the Design mode in Excel.

by DFT" command button. This will execute a program written in VBA (Visual Basic for Applications) which you can view by going into design mode (this is done by pressing the "design mode" button in the control toolbar as shown in Figure 5 and then double clicking on the command button). Executing the VBA code will result in two graphs being produced: the "raw" DFT, and the DFT corrected for sample frequency. Figures 6a, 6b, and 6c show an example with a test signal of 1,000 Hz.

Let's take a moment and talk about what is going on in this short program. After initialization of variables and constants, the sample signal is read into the array "Sample." Note that this is a 128 element array running from 0 to 127. So, our sample size is 128. Next we initialize two 65 element arrays to zero. The purpose of these arrays is to hold the values of the sines and cosines that make up the test signal (see Figure 7). (For reasons we won't go into here, cosines are referred to as the "real" part of the DFT while sines are the "imaginary" parts.)

Next, the test signal is correlated with sine and cosine basis functions. The correlation value with each basis function (remember, this is how "similar" two signals are to one another) is what gets stored in each element of the sine and cosine array. Finally, I merge the sine and cosine for each basis function into a root mean square value. This step is not really necessary, but I like to look at one final graph rather than two. If you prefer splitting sines and cosines apart, feel free to make two graphs.

We're not quite out of the woods yet, but we're close. All that remains is to convert those 65 basis functions in each array into meaningful frequencies that we can understand.

Remember, a processor is just crunching numbers in this DFT algorithm. It only sees samples, not voltages or frequencies. In order to convert to frequency, we multiply the sampling rate times the sample number and divide by the total number of samples.

Again, if any of this is unclear, look at the different Excel worksheets carefully. The cell formulas can be helpful. The "DTMF" worksheet demonstrates a useful application of the DFT. Instead of analyzing one signal, two can be broken down into their component frequencies and decisions can be made based on what is found.

Before wrapping up, there are a couple of items worth mentioning about the DFT.

Aliasing

You can only (reliably) sample signals with frequencies up to half the sampling frequency (called the Nyquist theorem). Sampling signals with higher frequencies will result in something referred to as aliasing. All this means is that the system is not sampling quickly enough to recognize the signal for what it is. In fact, the signal might be mistaken for something else.

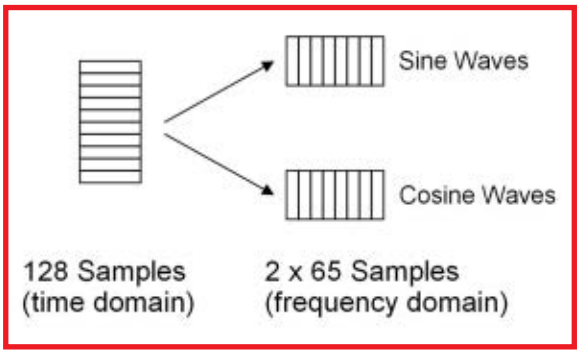


FIGURE 7. The 128 sample (time domain) array gets converted into two 65 sample (frequency domain) arrays.

To illustrate this, Figure 8a shows a 400 Hz sine wave. According to the Nyquist theorem, I need to sample this signal at a minimum of 800 Hz. Figure 8b shows the 400 Hz signal sampled at a frequency of 3 kHz, well above the Nyquist rate. If you mentally connect the dots, you can probably make out the original signal without much trouble. Figure 8c is our signal sampled at a 1 kHz rate, just a little above the Nyquist rate. While this may not look like a sine wave to you and me, it does to a DFT. Connecting the dots with a

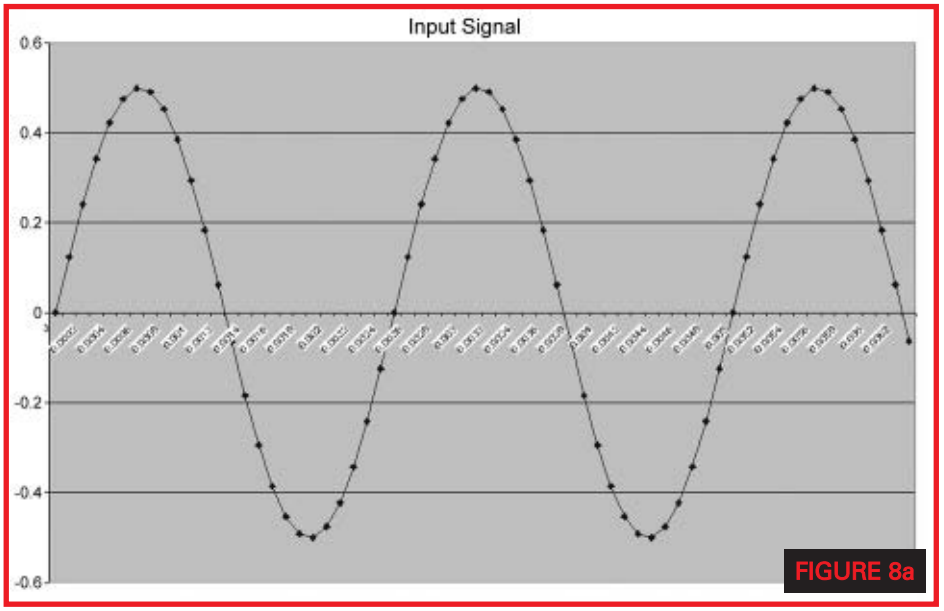


FIGURE 8a

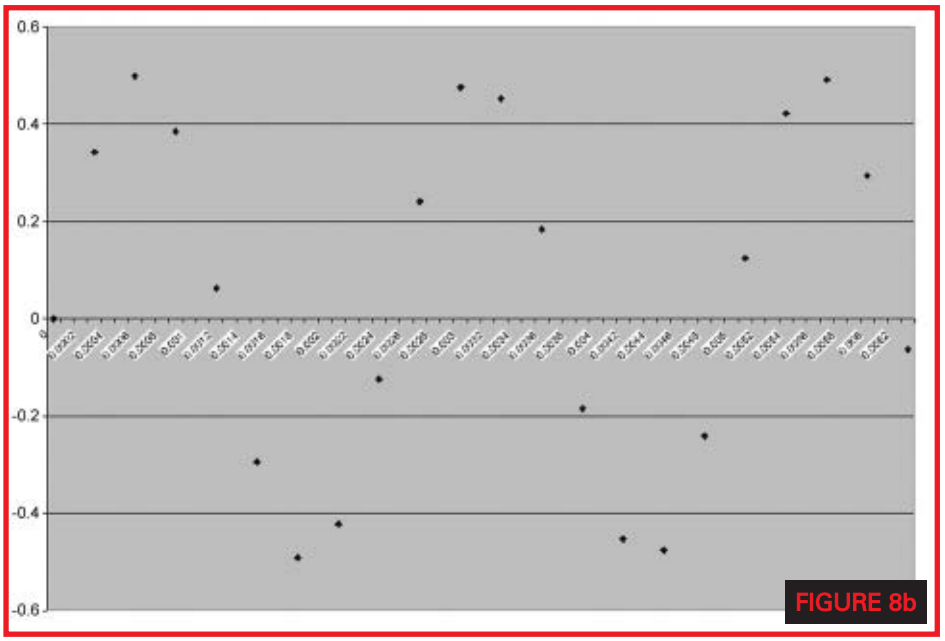


FIGURE 8b

Suggested Reading

Smith, Steven W., *The Scientist & Engineer's Guide to Digital Signal Processing*, 1997. This is a very popular book with clear and detailed explanations. Available for purchase, but is also free from **www.dspguide.com**.

Oppenheim, Alan V. et. al., *Discrete-Time Signal Processing*, 1999. This is a classic text on DSP. Heavy on the math and probably not appropriate for a hobbyist, but very thorough.

Press, William H. et al, *Numerical Recipes in C*. Contains many mathematical algorithms in C, including the FFT. A free pdf version is available at **www.library.cornell.edu/nr**.

Ideas for Exploration

To reiterate, my goal in this article was to give a brief overview of DFT theory and to provide the basic tools necessary to get you up and running with a DFT-related project. This is only a starting point. The possibilities from here are limitless. Here are just a few ideas:

1) Implement a DFT in a microprocessor and hook up a microphone or signal generator to an A/D input. Hints: Try to avoid aliasing (low pass filter required) and remember that a processor's input is typically 0 to 5 volts (level shifting required).

2) Try increasing the sample size in order to get more frequency resolution.

3) As the sample size increases, the DFT takes longer to run. Research and implement the fast Fourier transform (FFT). See suggested reading. For a real challenge, try to understand the FFT.

4) The DFT presented here was a forward transform (going from the time domain to the frequency domain). We can also go the other way. Try making a spreadsheet that will do an inverse DFT.

5) Built a low speed frequency analyzer using the DFT.

6) Explore specialized DSP processors. Manufacturers include Microchip, Analog Devices, and Texas Instruments. They all offer some kind of demo board.

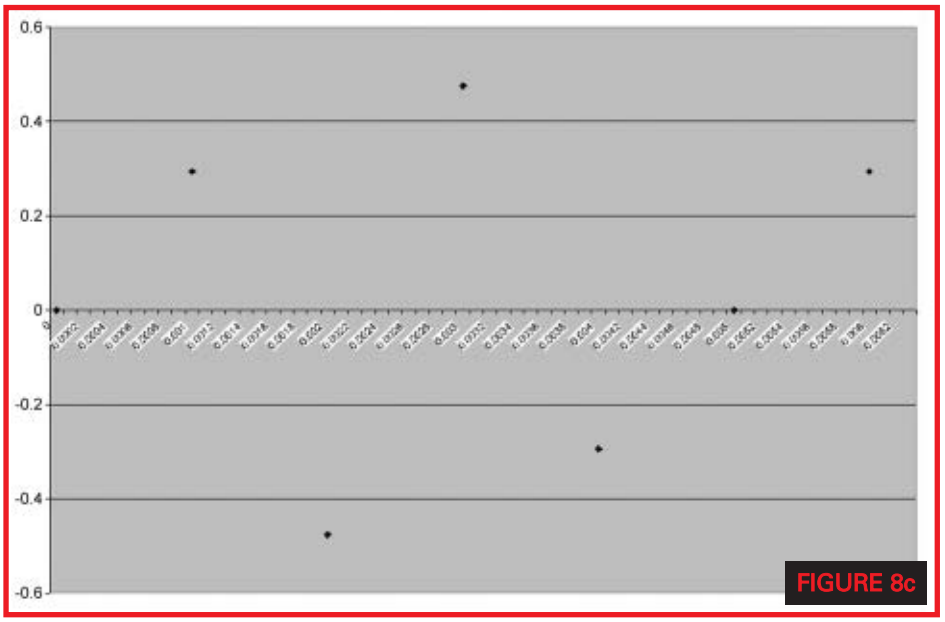


FIGURE 8c

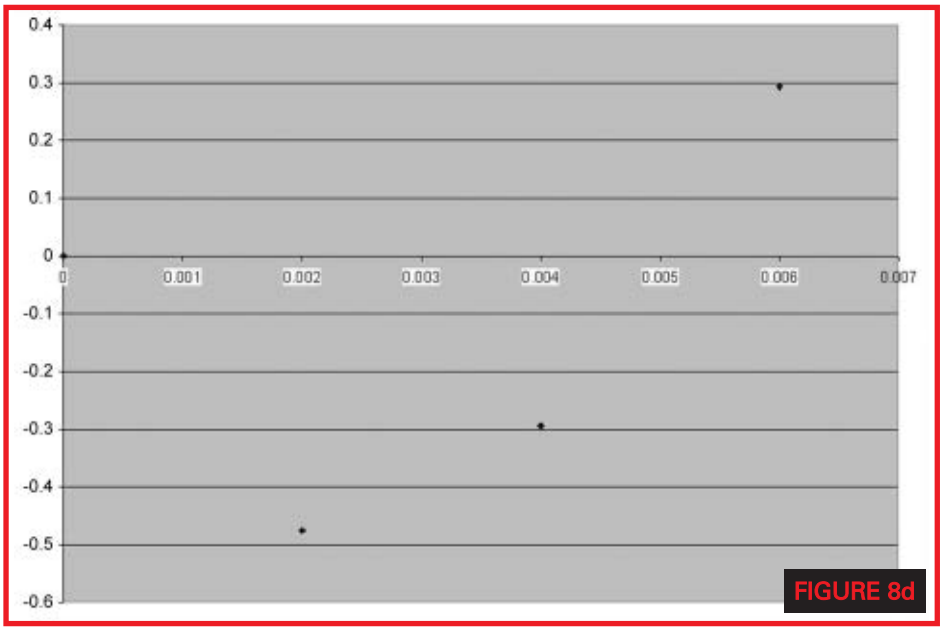


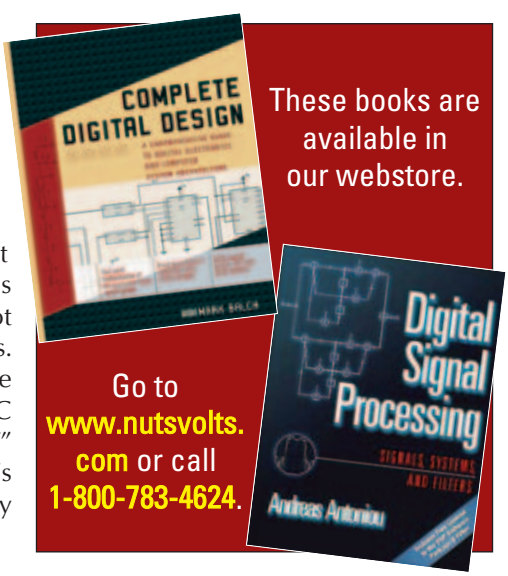
FIGURE 8d

smooth curve may help bring out the original sine wave a little better. Finally, Figure 8d is the signal sampled at 500 Hz, which is below the Nyquist rate. Not only is the 400 Hz sine wave no longer discernable, but connecting the dots actually suggests a sine wave of a lower frequency!

You can experiment with aliasing by going to the "DFT" tab and entering in a test signal frequency that is higher than half the sampling frequency (or lower the sampling frequency to get the same effect). You can also check out the "Aliasing" tab in the spreadsheet to see how I got these graphs.

DC Offset

There is one basis function that may not be obvious. Namely, a basis function with a frequency of zero. Not to worry, the DFT doesn't miss this. The 0th element in each of the sine and cosine arrays contains the DC offset of the signal. Go to the "DFT" tab and try changing the test signal's offset and see how that affects array element 0. **NV**



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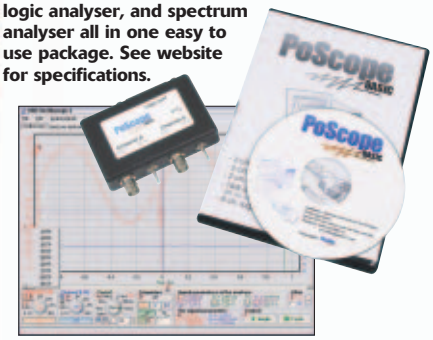

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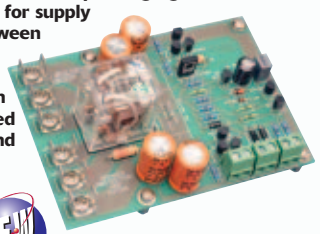

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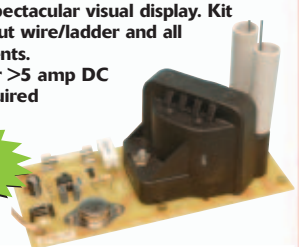

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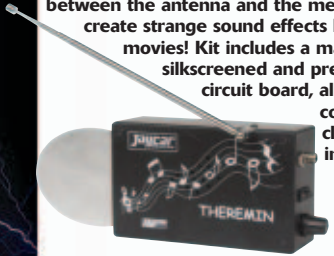

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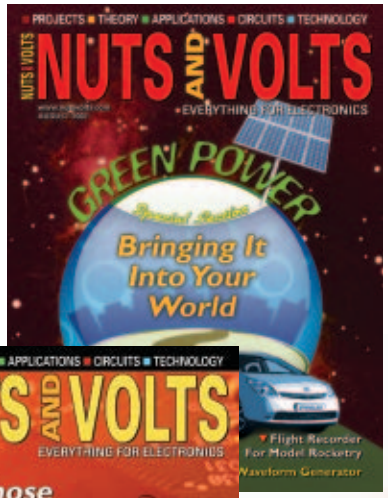

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A Logic Analyzer Tutorial

PART 2

Part 1 gave you an overview of logic analyzer basics. Now, let's concentrate on actually using this instrument. We'll examine some of its limitations and its numerous, powerful features that make it so useful in the lab, production line, academic and research environments, as well as in development and maintenance applications.

by Vaughn D. Martin

During hardware and software debug (system integration), it's helpful to have correlated state and timing information. You may initially detect a problem as an invalid state on the bus. Setup and hold timing violations may cause this. If the logic analyzer cannot capture both timing and state data simultaneously, isolating the problem becomes difficult and time-consuming. Some logic analyzers require connecting a separate timing probe to acquire the timing information and use separate acquisition hardware.

These instruments require you to connect two types of probes to the SUT (system under test) at once (see Figure 1). One probe connects the SUT to a timing module, while a second probe connects the same test points to a state module. This "double probing" arrangement can compromise your signal's impedance environment. Two probes will load down the signal, degrading the SUT's rise and fall times, amplitude, and noise performance. Figure 1 is a simplified illustration showing only a few representative connections. In an actual measurement, there might be four, eight, or more multi-conductor cables attached.

The Confusion of Double Probing

It is best to acquire timing and state data simultaneously through the

FIGURE 1. An illustration of how double probing requires two separate probes on each test point, which decreases the quality of the measured parameters sought.

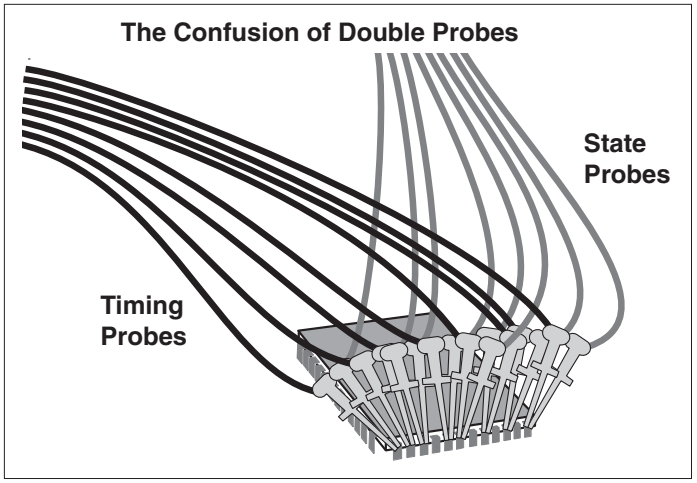
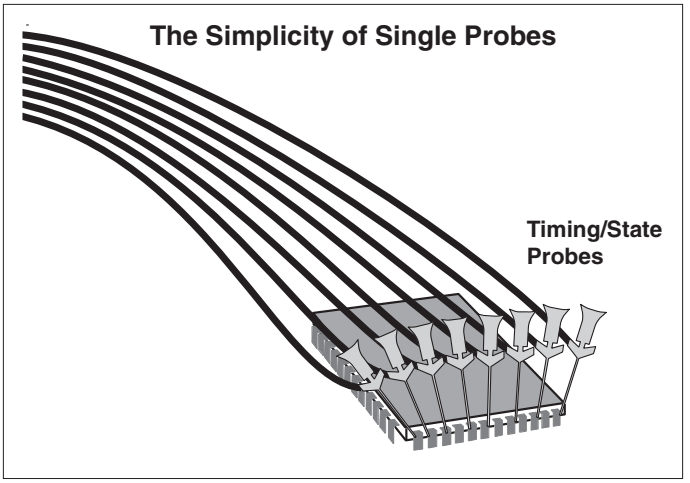


FIGURE 2. An illustration of how simultaneous probing provides state and timing acquisition through the same probe, which is a much "cleaner" measurement environment.



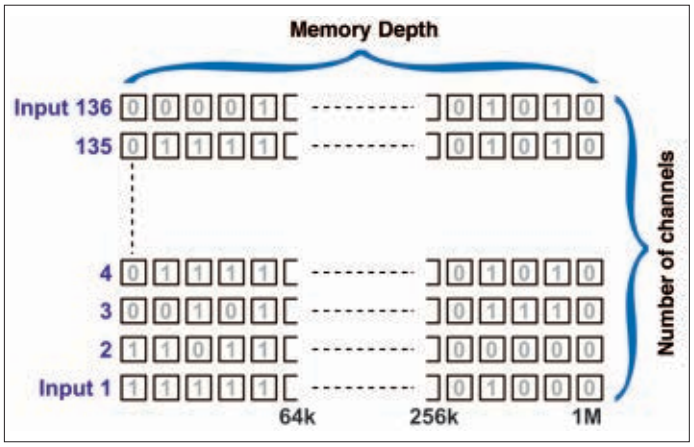


FIGURE 3. An illustration of how a logic analyzer can store acquisition data in a deep memory with one full-depth channel supporting each digital input.

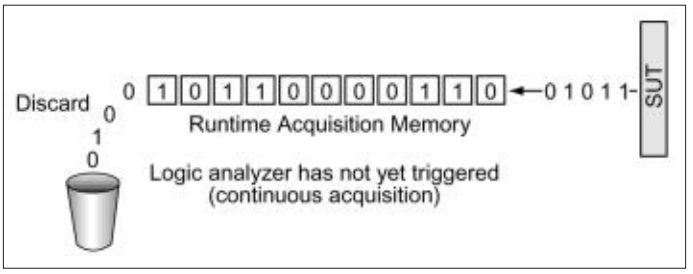


FIGURE 4. An illustration of how a logic analyzer can capture and then discard data on a first-in, first-out (FIFO) basis until a trigger event occurs.

same probe at the same time (see Figure 2). One connection, one setup, and one acquisition provide both timing and state data. This simplified mechanical connection reduces problems. Simultaneous timing and state acquisition allows your logic analyzer to capture all needed information to support both timing and state analysis.

There is less chance of errors and mechanical damage that can occur with double probing. The single probe's effect on the circuit is lower, ensuring more accurate measurements and less impact on your circuit's operation. The higher the timing resolution, the more details you can see and trigger on in your design. This increases your chance of finding problems.

Real-time Acquisition Memory

The logic analyzer's probing, triggering, and clocking systems deliver data to the real-time acquisition memory — the heart of the instrument. This is the destination for all of the sampled data from the SUT and the source for all of the instrument's analysis and display.

The logic analyzer memory stores data at the instrument's sample rate. Think of this as a matrix having channel width and memory depth (see Figure 3). The instrument accumulates a record of all signal activity until a trigger event or the user tells it to stop. The result is an acquisition — essentially a multi-channel waveform display that lets you view the interaction of all the signals you've acquired, with very precise timing.

For a given memory capacity, the total acquisition time decreases as the sample rate increases. For example, the stored data in a 1M memory spans one second of time when your sample rate is 1 µs. The same 1M memory spans only 10 ms of time for an acquisition clock period of 10 ns. Acquiring more samples (time) increases your chance of capturing both an error, and the fault that caused the error (see Figure 2 again). This illustrates how simultaneous probing provides state and timing acquisition through the same probe, for a simpler, cleaner measurement environment.

Logic analyzers continuously sample data, filling up the real-time acquisition memory, and discarding the overflow on a first-in, first-out basis, as shown in Figure 4. Thus, there is a constant flow of real-time data through the memory. When the trigger event occurs, the "halt" process begins, preserving the data in the memory.

The placement of the trigger in the memory is flexible, allowing you to capture and examine events that occurred before, after, and around the trigger event. This is a valuable troubleshooting feature. If you trigger on a symptom — usually an error of some kind — you can set up the logic analyzer to store data preceding the trigger (pre-trigger data) and capture the fault that caused the symptom. You can also set the logic analyzer to store a certain amount of data after the trigger (post-trigger data) to see what subsequent effects the error might have had.

Other combinations of trigger placement are available (see Figures 5 and 6). With probing, clocking, and triggering set up, the logic analyzer is ready to run. The result will be a real-time

FIGURE 5. An illustration of how a logic analyzer can capture data that occurs a specific number of cycles later than the trigger.

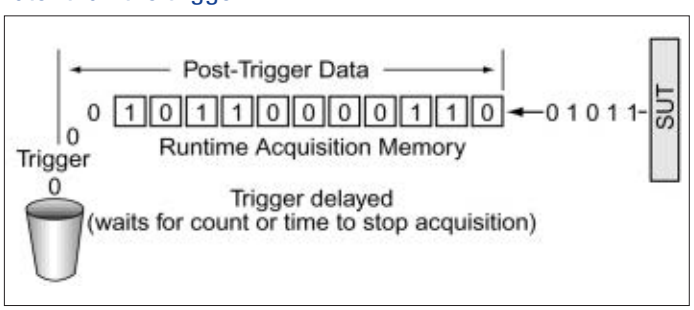
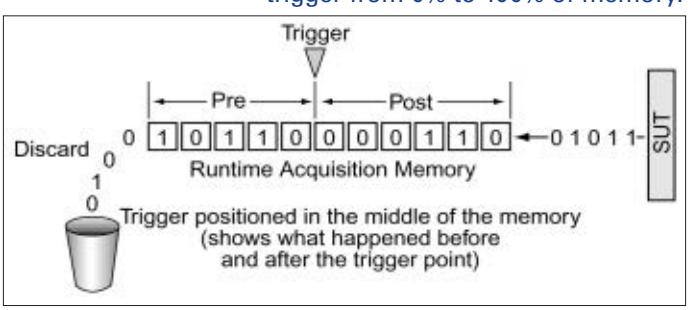


FIGURE 6. An illustration of how a logic analyzer can capture data around the trigger. Data to the left of the trigger point is "pre-trigger" data, while data to the right is "post-trigger" data. You can position the trigger from 0% to 100% of memory.



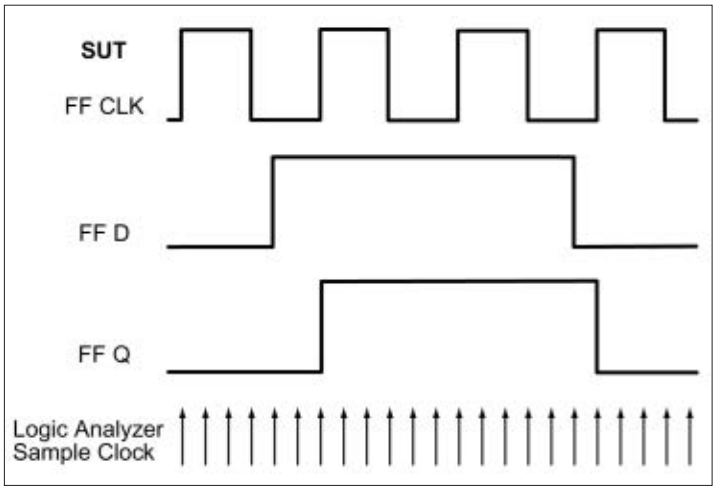


FIGURE 7. An illustration of a logic analyzer's display, (somewhat simplified) so it remains uncluttered for discussion purposes.

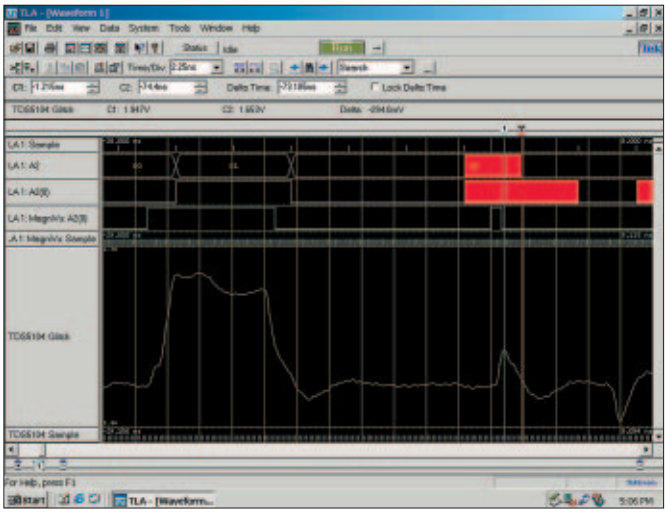


FIGURE 8. A time-correlated analog/digital view of an anomaly.

acquisition memory full of data that can be used to analyze the behavior of your SUT in several different ways.

Analysis and Display

The data stored in the real-time acquisition memory can be used in a variety of display and analysis modes. Once the information is stored within the system, it can be viewed in formats ranging from timing waveforms Figure 7) to instruction mnemonics correlated to source code.

In newer systems with faster clock edges and data rates, this is no longer the case. As design margins decrease, analog characteristics of digital signals increasingly affect the integrity of your digital system. A time-correlated analog-digital display using a logic analyzer with an oscilloscope gives you the ability to see the analog characteristics of digital signals in relation to complex digital events in the circuit, so you can more easily find the source of anomalies (see Figure 8.)

The listing display provides state information in user-selectable alphanumeric form. The data values in the listing are developed from samples captured from an entire bus and can be represented in hexadecimal or other formats. Imagine taking a vertical "slice" through all the waveforms on a bus (see Figure 9). The slice through the four-bit bus represents a sample that is stored in the real-time acquisition memory. Figure 9 shows the numbers in the shaded slice are what the logic analyzer would display, typically in hexadecimal form.

The intent of the listing display is to show the state of the SUT. The listing display in Figure 10 lets you see the information flow exactly as the SUT sees it as a stream of data words.

State data is displayed in several formats. The real-time instruction trace disassembles every bus transaction and determines exactly which instructions were read across the bus. It places the appropriate instruction mnemonic, along with its associated address, on the logic analyzer display.

Figure 11 is an example of a real-time instruction trace display. An additional display — the source code debug display — makes your debug work more efficient by correlating the source code to the instruction trace history. It provides instant visibility of what's actually going on when an instruction executes. Figure 12 is a source code display correlated to the Figure 11 real-time instruction trace.

With the aid of processor-specific support packages, you can display

FIGURE 9. An illustration of how a logic analyzer's state acquisition captures a "slice" of data across a bus when the external clock signal enables an acquisition.

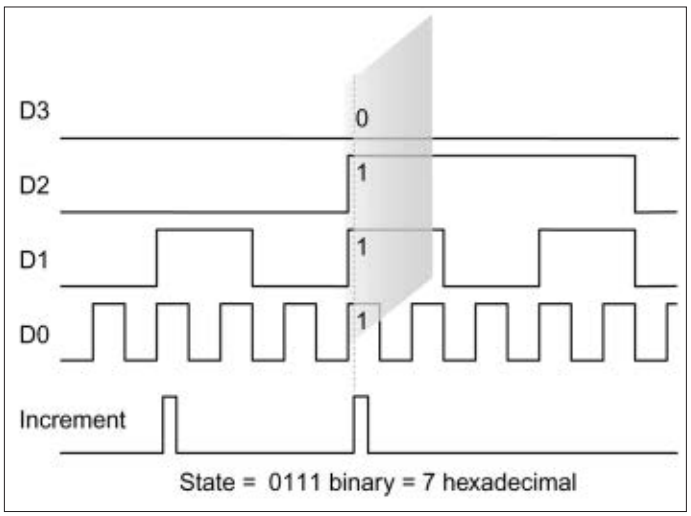


FIGURE 10. A display listing.

Sample	Counter	Counter	Timestamp
0	0111	7	0 ps
1	1111	F	114.000 ns
2	0000	0	228.000 ns
3	1000	8	342.000 ns
4	0100	4	457.000 ns
5	1100	C	570.500 ns
6	0010	2	685.000 ns
7	1010	A	799.000 ns

state analysis data in mnemonic form. This makes it easier to debug software problems in the SUT. Armed with this knowledge, you can go to a lower-level state display (such as a hexadecimal display) or to a timing diagram display to track down the error's origin.

State analysis applications include:

- Parametric and margin analysis (e.g., setup and hold values).
- Detect setup and hold timing violations.
- Hardware/software integration and debug.
- State machine system optimization: line 31 in Figure 12 is correlated with sample 158 in the instruction trace display of Figure 9.
- Capture and analyze real-time system operation in order to debug, verify, optimize, and validate the design.

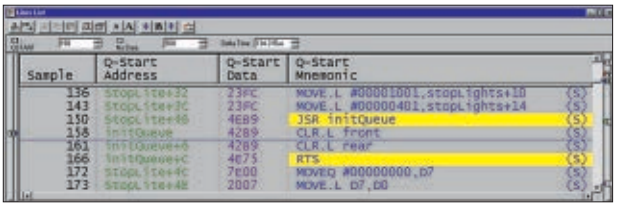
This trend — the virtual substitution of the logic analyzer for the traditional microprocessor emulation tool (in-circuit emulator or ICE) — continues today. The result, therefore, is that those who need the principal function of a logic analyzer — the selective acquisition of digital data and its display as a pattern of waveforms — have a tool that has a different emphasis and high cost.

Monitoring microprocessor CPUs is easier with states translated into assembly code, so this type of capability was available as a logic analyzer option for each common µP IC family. However, integrated hardware and software control was not generally possible with logic analyzers. This labor-intensive process usually involved writing the software, then compiling/assembling it, translating it into a downloadable format, and then downloading it into the system. The logic analyzer then monitored the new software version.

An In-Circuit Emulator

This is a collection of hardware and software. The hardware consists of a host computer system (typically

FIGURE 11. A real-time instruction trace display.



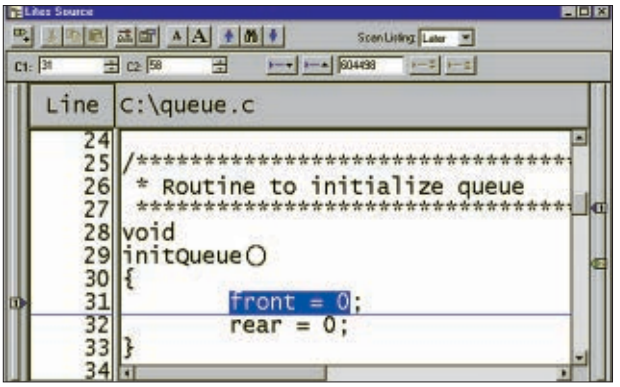


FIGURE 12. Source code display. Note that line 31 correlates to sample 158 in the instruction trace display in Figure 9.

significantly more powerful than the CPU of the system being emulated) and an interface to the target processor's socket. The interface consists of logic and a cable which plugs into the socket intended for the target processor. The hardware and software work together to allow the target system to debug it under your control. The cable takes the place of the microprocessor IC, or connects to the µP IC and disables the µP IC to allow host system control.

Newer systems allow the same sort of debug capability with a simpler hardware interface. Debug and test hardware is built into a microcontroller, which is a microprocessor-based system on a chip. The system includes many standard peripherals such as serial interfaces, parallel interfaces, timers, priority interrupt controllers, clock management circuits, a simple high-speed serial interface, possibly USB port hardware, and — most importantly — a four-wire test interface that IEEE 1149 specifies and Joint Test Architecture Group (also known as JTAG) manages.

This JTAG interface came into existence to support the boundary scan test of ICs, but is so versatile you can use it to populate nonvolatile system memory and program logic devices such as CPLDs in place. The JTAG is a serial bus which you can daisy chain that allows you to test and/or program many devices.

System designers program PALs, PLAs, and more recently CPLDs. The configuration is unknown until you decide the programming, so the manufacturer cannot completely test the parts. Unless you select pins for test points, making them generally unavailable for functional use.

There is no internal circuit access for use with a logic analyzer. Therefore, programmable logic support software must include a simulator to allow you to conceptually test the simpler designs and ultimately generate test vectors to verify the correct programming of these parts. The device programmer uses the test vectors for simpler devices, such as PALs and PLAs.

Use of the JTAG port on newer, more complex devices allows testing of the devices you have programmed and placed in the circuit. JTAG-equipped devices require only a four-pin penalty to support this flexibility.

You can use simpler logic analyzers to test the remaining circuits on a system with microcontrollers and dense programmable parts like CPLDs. Cards which you can implement as a PC peripheral board need to only have simple state measurement and trigger capabilities which you can control and expand by the PC. Logic analyzers are therefore useful for tracing down glitches in the "glue" logic. **NV**

Acknowledgements

I wish to thank Matt Litfin of Tektronix for both supplying artwork, as well as reading the finished manuscript, ensuring its technical accuracy, and John Stabler, my boss, for information related to in-circuit emulators and the JTAG.

DIGITAL TV — Ready or Not, Here it Comes!

February 17, 2009 — a date that may not live in infamy, but nevertheless will witness a monumental change in the US television broadcasting landscape. On that date, all high power analog TV transmissions will cease, marking the end of nearly 80 years of almost continuous operation across the country. While some LPTV (low power TV) and repeater stations may continue to operate, suffice it to say that most American TV watchers will be affected in one way or another by this change.

by Jeff Mazur

For the majority of us who receive our TV signals via cable, telcos, or DBS (direct broadcast satellite), this event should pass with hardly a blip on our screen. There may be a slight interruption while broadcasters change transmitters and set-top boxes are reprogrammed from the head end to receive many stations on their new frequencies.

Cable networks (Lifetime, CNN, etc.) — including premium channels (e.g., HBO and Showtime), as well as PPV (Pay-Per-View) and VOD (Video-On-Demand) services — will not be affected. Current plans even have some cable companies supplying analog signals (converted from the new digital transmissions) so that any TVs connected directly to the cable (i.e., without a set-top box) will continue to function.

It is likely, however, that prior to the 2009 shutdown, the number of existing analog channels on the cable will be trimmed to a minimum. Of course, your DVD and VCR will still work but don't plan on recording any shows off air unless the recorder has a digital tuner.

HISTORY OF US TV

The analog TV system still in use today was designed in the early 1930s for monochrome (black and white) broadcasting. This system was later revised in 1953 by the National Television System Committee (NTSC) to accommodate color. At that time, it was an important goal to devise a scheme to add color information in a way that was compatible with the existing monochrome signal. This was indeed accomplished (although not before a brief fling with a field sequential color wheel system devised by CBS) and it is a testament to those engineers that the system has remained viable all of these years with virtually no enhancements.

When an improved High Definition TV (HDTV) system first began to be considered, it was assumed that a higher bandwidth analog signal would be required. A few schemes were developed which placed the extra picture resolution on additional subcarriers. This would have resulted in a system that could offer compatibility with the existing NTSC signal. Unfortunately, the extra bandwidth this required made these systems impractical. Digital systems were in their infancy and compression technology practically did not exist at that time.

In other countries, most notably Japan, the push towards HDTV seemed inevitable and a few standards began to appear. In the US, there was a strong political pressure to create a new system that was better than anything else already in use. To this end, in 1987 the FCC (Federal Communications Commission) created the Advisory Committee on Advanced Television Services (ACATS) and empowered it to research all existing technologies. With help from the Advanced Television System Committee (ATSC), an open call was put out for Advanced Television (ATV) system designs and 23 competing analog systems were submitted.

After a long review process however, it became apparent that a digital system would be much more desirable, despite the fact that this would mean rolling out a completely new system that would not be compatible with the existing NTSC standard. By 1993, there were four digital systems being considered.

In the end, the ACATS could not pick a single system as clearly better than the rest. With time running out, the four remaining participants agreed to combine their best efforts into a single system and thus formed the HDTV Grand Alliance (GA). At the last minute, the computer industry decided to weigh in and several minor changes were made.

By 1996, the GA system was brought to the FCC for approval and in April 1997 the FCC prepared to

start issuing licenses for the new broadcasts. Despite the protest of some who felt that the new licenses should be auctioned off (with the proceeds going to reduce the national debt), the FCC decided to give all existing TV stations a second channel for Digital TV (DTV) broadcasting if they so desired. This was deemed necessary considering the million-dollar-plus cost that each station would incur to make the transition to digital.

Money was not the only stumbling block facing a nationwide implementation of DTV. A great deal of effort went into the assignment of new channels (mostly in the UHF spectrum) to avoid interference between the new stations, as well as to reduce interference with — and from — the existing NTSC stations which would remain on the air for many years during the transition.

The exact date for the NTSC stations to go dark has been changed several times, mostly due to the huge task of installing new antennae and transmitters for over 1,700 existing commercial TV stations. But the latest legislation (DEFICIT REDUCTION ACT OF 2005, Title III — Digital Television Transition and Public Safety Act) firmly calls for the end of most NTSC broadcasting on February 17, 2009.

Why call it the "Digital Television Transition and Public Safety Act?" One of the reasons for the transition to DTV is to free up a portion of the UHF band, which will be given to Homeland Security for first responders. When analog broadcasts cease in the 700 MHz spectrum (current Channels 52-69), those frequencies will be used to improve communications between police, firefighters, etc. Any revenue generated from the sale of this spectrum will be used to offset federal deficit spending.

WHAT DOES IT ALL MEAN?

With the demise of analog transmissions, TVs and other off-air recording devices will require a digital (a.k.a., ATSC) tuner to receive them free, over the air terrestrial broadcasts. All televisions sold since March of this year have been required to have such tuners built in (technically, the law only requires this of sets shipped in interstate commerce or imported into the United States). This, of course, is in addition to the standard NTSC tuner that is still needed to receive analog signals until 2009.

Older sets will require a converter box between the antenna and TV to translate the digital signals into an analog signal that the TV can receive. Starting in 2008, a federal program will commence to provide $40 vouchers towards the purchase of up to two converters per household. More on this later.

So does this mean that all TVs with a digital tuner or converter box will display HDTV? Unfortunately, the answer is NO! Every digital broadcast can carry one or more programs, each of which can be in one of 18 different formats (see Table 1).

Each station broadcasts a 19.39 Mbit/s (million bits per second) data stream which can be divided into any number of different signals or services. Most video streams will be either Standard Definition TV (SDTV) or HDTV; many Extended Definition TV (EDTV) formats are defined but none are currently in common use.

DTV pictures are clearer due to several factors: no NTSC artifacts (moiré and chroma crawl), less interference (static and impulse noise), and no multipath distortions (ghosts and airplane flutter). Audio quality is also vastly superior, with 5.1 surround sound channels widely used.

HDTV

Probably the most exciting part of the DTV standard is the inclusion of two basic HDTV formats that allow much higher resolution images. Both 720p60 and 1080i30 formats are in widespread use by the major networks. The other major difference with HDTV is the wider aspect ratio of the screen — 16:9 vs. the old 4:3. This widescreen aspect gives a more "movie theater like" experience and allows most films to be broadcast

	Vertical Lines	Horizontal Pixels	Aspect Ratio	Frame Rate
HDTV	1080	1920	16:9 sq	60i, 30p, 24p
	720	1280	16:9 sq	60p, 30p, 24p
EDTV	480	704	16:9 ns	60p, 60i, 30p, 24p
	480	704	4:3 ns	60p, 60i, 30p, 24p
	480	640	4:3 sq	60p, 30p, 24p
SDTV	480	640	4:3 sq	60i
NTSC	486	720	4:3 ns	60i*

Vertical lines = number of active lines in the picture
Horizontal pixels = number of active pixels (picture elements) per line
Aspect ratio = ratio of picture width to picture height/pixel aspect ratio
sq = square pixels; ns = non-square pixels
Frame rate = number of frames (p) or fields (i) per second
p = progressive scanning; i = interlaced scanning
Rates may be based on either 60 Hz or 59.94 Hz
* = based on ITU-R BT.601 specification

1080-line video is actually encoded with 1920×1088 pixel frames, but the last eight lines are discarded prior to display. This is due to a restriction of the MPEG-2 video format, which requires the number of pixels to be evenly divisible by 16.

TABLE 1

Progressive vs. Interlaced

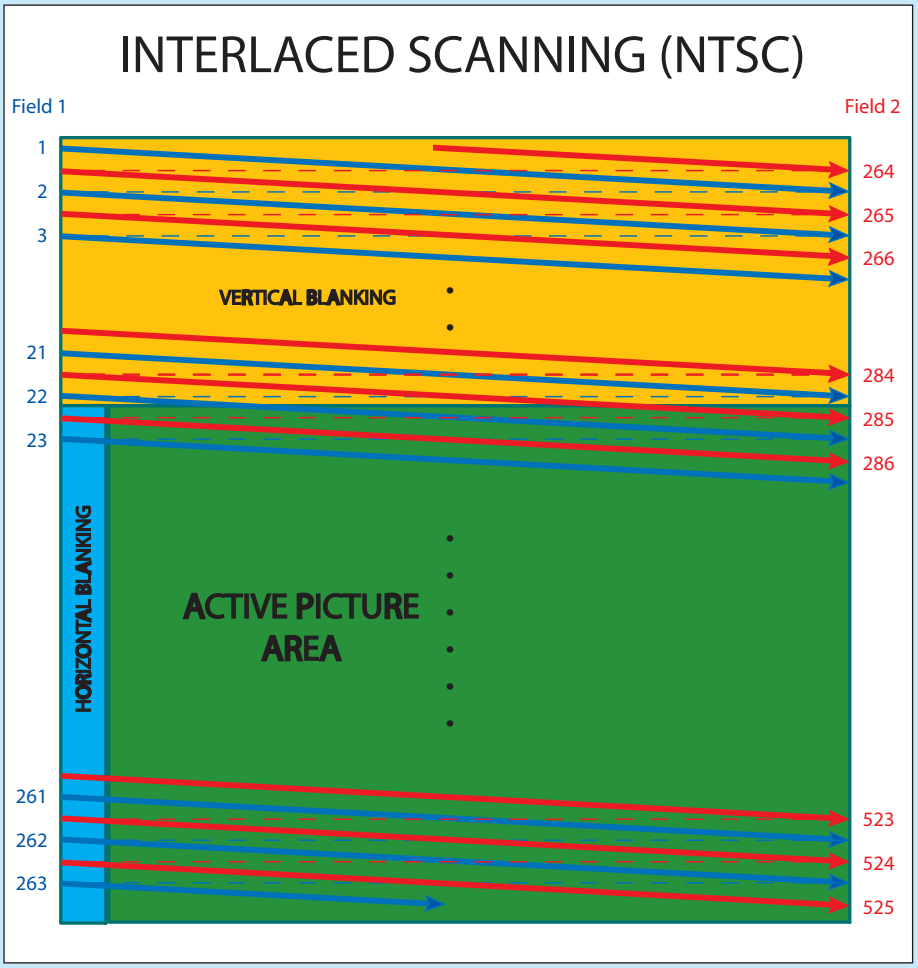
All analog TV systems use interlaced scanning which breaks each frame of video into two fields. One field displays every other line of the picture from top to bottom; then on the next field, the previously skipped lines are displayed. Interlaced scanning was developed as a way to keep the display rate high enough to avoid flicker while keeping the bandwidth requirements for the TV signal to a minimum.

While it does meet these goals, it adds further complexity by representing two distinct samples in time. That is, every other line represents not only different spatial information but also different temporal information. This can result in a jagged appearance when both fields are viewed together. Progressive scanning, as used by all computer displays, does not have this problem.

Since most TVs sold today (LCD, DLP, plasma) display progressive images natively, this seems a logical choice for any new TV standard. Progressive images are also much easier to compress digitally. Only CRT based displays still offer interlaced scanning and it's becoming almost impossible to find consumer CRT based products.

To deliver a clear picture of nterlaced material on a progressive display, digital processing is used to perform de-interlacing and line doubling. Material shot at 24 fps (frames per second) — whether film or video — usually undergoes a process known as 3:2 pull-down to convert it to 60 fields per second video, thus introducing interlace.

Digital processing can also be used to recognize such material and reverse this process to recover the clean progressive frames. Some of the latest TV sets being sold now offer a 1080p60 display capability. Although no material is being broadcast in this format, the new HD-DVD and Blu-ray players, as well as some video game consoles, can provide images in this format with exceptional results.



without resorting to the letterbox or pan-and-scan techniques used in the past.

On the other hand, when standard 4:3 material is displayed on a widescreen TV, there will now be unused picture area on the sides (pillar box) unless the image is zoomed or stretched to fill the screen.

While it is possible for any broadcaster to transmit any format in Table 1 at any time, most have settled on a single HDTV format. ABC, ESPN, and FOX have chosen 720p. All other networks are using 1080i.

The pros and cons of these two HD formats have been the subject of much debate. In general, 1080i offers greater spatial resolution using the same frame rate and interlace structure of the current SD signal. The progressive 720p format eliminates all of the artifacts and production issues associated with interlaced scanning and doubles the frame rate, as well. This increases the temporal resolution and allows much smoother motion for fast moving scenes like sporting events. But it does this at the expense of less spatial resolution (less pixels). (See the sidebar Progressive vs. Interlaced)

Another debate is how the Kell Factor affects interlaced scanning. All sampled, scanning systems suffer from this effect which is due to picture information that does not fall exactly on the samples (e.g., details that are between the scan lines). Since interlaced scanning has much greater spacing between each scan line of a given field, the net effect is to reduce its resolution to about 70% of the actual number of scan lines. Thus, one might argue that the 1080i format really only gives slightly more spatial resolution than 720p.

As if these two HD formats weren't enough, almost all high-end production is now being done at 1080p24. This offers the advantages of both high resolution and progressive scanning, but trades this for an even slower frame rate. This rate matches that of film production, so it offers a reasonable compromise and can easily be converted to either 720p or 1080i. Newer production gear is

just starting to appear which portends a possible move towards 1080p60; this would be an ideal format but requires higher bandwidth, more storage, etc. It currently cannot be broadcast.

All of these HDTV standards require much higher bandwidth to carry the uncompressed signal. For example, in broadcast studios an SD signal is carried digitally by a 270 Mbit/s signal, while HD requires 1.5 Gbps (3 Gbps for the 1080p60 signal). Therefore, to carry this signal along with audio and other data on the 19.39 Mbit/s ATSC data stream requires a great deal of compression. At roughly 100-to-1, this video compression is not hard to see if you look closely at an HDTV screen. These video artifacts mostly show up as a blockiness or chunky appearance easily seen on small text or graphics. At proper viewing distance however, the picture does live up to its promise of high definition compared to SDTV.

DIGITAL TRANSMISSION FORMAT

For transport, ATSC uses the MPEG (Moving Picture Experts Group) specification known as a transport stream to encapsulate data. First, the video is encoded using a VBR (Variable Bit Rate) MPEG-2 codec. Audio is encoded using Dolby Digital AC-3 which allows for the transport of up to five channels of sound with a sixth channel for low-frequency effects (commonly referred to as 5.1 audio).

Once the video and audio signals have been compressed, additional Program and System Information Protocol (PSIP) and Forward Error Correction (FEC) data is added. By the way, it is the PSIP data that tells a digital tuner what channel to call this stream, regardless of the actual RF channel used for transmission. This is how a digital TV can marry channels 7.1, 7.2, etc., carried on a UHF channel with the analog channel 7 carried on the actual VHF channel.

In addition to audio and video, data services such as captioning for the hearing impaired and/or a video description audio channel for the visually impaired can also be included. Multiple video, audio, and data streams are then fed into a statistical multiplexer (a.k.a., a stat-mux) which combines these signals into the transport stream. The stat-mux can prioritize the various signals so that the main channel carrying an HD signal will be given enough data bits to provide a clear picture, if necessary at the expense of the secondary SD or lower channels.

The transport stream is then used to modulate an RF carrier using eight-level vestigial sideband (8-VSB) creating a signal that occupies the same 6 MHz channel as used by today's analog system. Cable TV systems have a higher signal-to-noise ratio and can use 16-VSB or 256-QAM (Quadrature Amplitude Modulation) to achieve a throughput of 38.78 Mbit/s, within the same 6 MHz bandwidth. Most digital cable systems also use QAM to squeeze up to 10 SD channels into the same space formerly used by one analog channel.

Almost as soon as the ATSC standard was approved, there was dissent from some who felt that the 8-VSB modulation scheme was inadequate for mobile or handheld use. Coded Orthogonal Frequency-Division Multiplexing (COFDM) is widely known to offer much better performance in these situations (thus their adoption by both DVB and ISDB, discussed next).

One organization did extensive testing and even tried unsuccessfully to get the FCC to change this part of this standard. The 8-VSB scheme does have certain advantages, though, especially in rural markets where a single transmitter needs to serve a wide area.

It requires only about 10% of the transmitter power levels currently being used by analog broadcasts. Unfortunately, indoor reception (a la "rabbit ears") may not be possible in many locations. Thus, we may see a resurgence in the number of outdoor antennae populating our rooftops.

While the fact remains that the current VSB transmission makes mobile use nearly impossible, there are new methods being investigated to address this need. ATSC-H (handheld) and ATSC-M (mobile) standards are being developed, as well as third party solutions such as MPH (Mobile-Pedestrian-Handheld) and A-VSB (Advanced VSB). These methods add a secondary channel which, when used in conjunction with the main channel and/or better compression methods such as MPEG-4, present a useable picture in the face of lower and varying signal levels plus high degrees of multipath distortion.

By the way, although the ATSC system developed for US broadcasters has been adopted by other countries (e.g., Canada, Mexico, and South Korea), it is not the only digital TV broadcasting system. Most of Europe has chosen to use the DVB (Digital Video Broadcasting) system while Japan and others have opted for Integrated Services Digital Broadcasting (ISDB).

These systems both use COFDM for transmission. The fact that they all are based on MPEG-2 technology

Further Information

www.dtv.gov/
FCC website for information on the DTV transition.

www.atsc.org/
ATSC website for all technical details on DTV including the formal standards documents (e.g., see A/53E: "ATSC Digital Television Standard," the primary document governing the standard).

http://novia.net/~ereitan/index.html
Great site that chronicles the development of color TV, including the short-lived CBS field-sequential system.

http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-06-1082A2.pdf
Document that shows tentative channel assignments for all broadcast stations.

does offer much higher worldwide compatibility than the current NTSC vs. PAL vs. SECAM multi-standard situation.

WHAT'S THE BOTTOM LINE?

According to a recent survey by the Association of Public Television Stations (APTS), the majority of US households that receive their television signals over the air are still unaware of the digital TV transition. That's an estimated 22 million over-the-air homes that need to make some kind of digital decision by February 17, 2009. Even among those who were aware of the transition — after all, DTV broadcasts have been going on for over nine years and there's plenty of HDTV hype on air and in electronics stores — over half had no idea when analog transmissions were scheduled to be turned off.

Perhaps even more disturbing is the fact that almost half of those purchasing a new HDTV don't know they need to or don't plan on hooking it up to a source of HD signals. Some see the "HDTV where available" icons superimposed at the beginning of HD programs and automatically think they're seeing it in HD. Granted, for some, the quality of their new TV set is so much better than their previous CRT clunker that, in comparison, they ARE seeing higher definition. But clearly there needs to be more public education on the facts surrounding the DTV and HDTV transition. Congress has even set aside funding for consumer education and we should begin seeing large scale campaigns by the end of this year.

Broadcast stations have their own agenda to complete the transition, as well. They each face one of three scenarios on February 17. Those that have elected to keep their temporary DTV channel assignment after the transition have the easiest job — they just simply turn off their analog transmitter. Thanks to their PSIP, they will continue to be known by their previous channel number despite being physically transmitted on a different "channel."

Other stations have opted to move back to their original channel or to a completely new channel on February 18. This poses a greater challenge, especially for digital UHF channels that move back to a VHF channel. These stations will have already upgraded their VHF transmitters to newer "digital ready" units or perhaps have split their existing transmitter to allow the conversion to take place in two separate phases. At switchover, they may require a short period of downtime to reconfigure and tune up the transmitter for its new operation. You can check out the plans of your local stations by going to the FCC link provided in the sidebar.

For viewers (at least those who receive their TV signals over the air), the decision to be made by 2009 is clear: either 1) sign up for cable or other subscription based television delivery service; 2) buy a new digital TV, or 3) purchase a converter box for each analog TV. To help prevent the final DTV holdouts from staring at a blank screen on February 18, a digital-to-analog converter box coupon program will be launched by the Department of Commerce's National Telecommunications and Information Administration (NTIA).

Between January 1, 2008 and March 31, 2009, all US households will be eligible to request up to two coupons — worth $40 each — to be used toward the purchase of digital-to-analog converter boxes. While not available yet, it is estimated that such boxes will sell for around $50.

Initially, these coupons will be available to everyone; but they may later be restricted only to households with no other means of receiving TV other than off air. Details on how to apply for these coupons will be established later this year. **NV**

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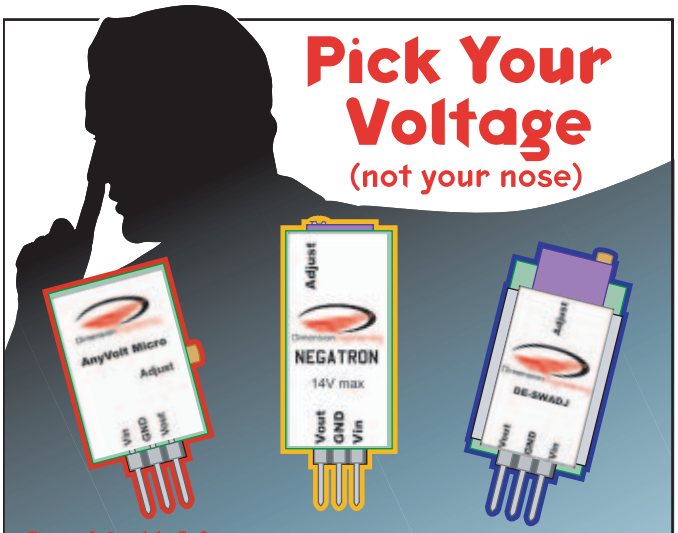

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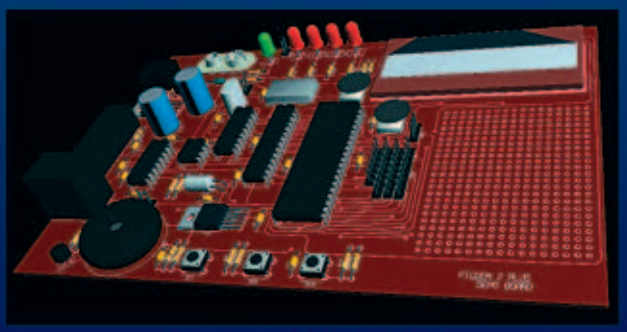

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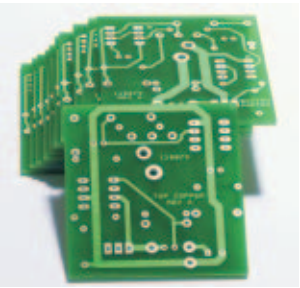

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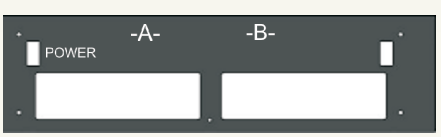

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BY LOUIS E. FRENZEL W5LEF

HD RADIO IN YOUR FUTURE? Modern Digital Radio — Better Than You Think

I JUST FINISHED TESTING RADIOSOPHY's new HD100 digital radio and was impressed enough to want to tell you about it. In case you are still in the dark about this radio technology, HD radio is the digital radio service that is available along with your regular AM and FM radio stations. Many — actually, most — radio stations today have elected to supplement their regular analog AM and FM programming with HD digital. Amazingly, AM radio broadcasting has been around since the 1920s while FM broadcasting has been available since the late 1930s. Both are still going strong today and you are probably one of those who use them regularly, even though everything else has gone digital or is linked to the Internet.

If you haven't tried HD radio yet, you are missing one of the enhancements that should keep AM and FM radio healthy for years to come in an Internet world.

HD FOR BEGINNERS

Digital broadcast radio has been around for years. Not in the US so much, but in Canada, Europe, Japan, and other parts of the world. Called Digital Audio Broadcasting (DAB), it puts the voice and music in digital form and transmits it to special consumer receivers. The Federal Communications Commission (FCC) approved of HD digital radio for the US back in 2002.

The system adopted is one created by iBiquity Digital Corporation of Columbia, MD. It is a very clever system that puts the digital signal right below the existing AM or FM analog signal in the same bandwidth. So the result is that no new spectrum is needed as was the case for DAB in the VHF bands.

AM and FM stations still broadcast their regular analog programming but with HD, a separate signal is added to the output on the same frequency with essentially the same channel. This signal contains one or more digital streams of voice, music, or data. If you have an HD receiver, you can get the digital signals.

To squeeze digital signals into such a narrow bandwidth (10 kHz channels for AM and 150 MHz for FM), some form of digital compression is required. Compression is a technique that takes a digitized audio signal and puts it through a mathematical process that effectively reduces the number of bits needed to represent the information.

For example, MP3 is a music compression technique that allows you to store many digital songs in a Flash memory or small hard drive in an iPod or iPod-like device. The compression standard used by iBiquity is a variation of the AAC+ audio compression standard. It is a very efficient compression as it lets you put high quality audio into fewer bits that results in slower data rates that, in turn, results in less overall bandwidth of the sidebands. Audio compression is also widely used in all cell phones.

There are literally dozens of different methods of compression, some more efficient than others. The big issue is that the process of compression causes some of the original data to be lost or compromised. For that reason, when you decompress the audio for playback, the sound recovered is somewhat different than the original ... usually not quite as good.

So the whole issue in digital compression is to find one that does the least amount of damage. And of course, audio quality is not something that is fixed. It is a very subjective human kind of thing. Some will think the audio is great while others will

think it is worse. So the goal is to test the various methods enough to get one that everyone can live with.

Once the audio is compressed, it is subjected to the modulation process. In this case, orthogonal frequency division multiplexing (OFDM) is used. To create OFDM, you use a mathematical technique called the inverse fast Fourier transform (IFFT). This process effectively creates multiple radio carriers of a very narrow bandwidth that are each modulated by one part of the digital bit stream. The result is that the data is transmitted as many parallel or simultaneous carriers over a wide bandwidth.

The only practical way to do this is to implement the whole IFFT process on a digital signal processor (DSP) chip running the OFDM software. At the receiver, the signal is demodulated and put through a DSP running FFT to recover the original bit stream. The bit stream is then sent to digital-to-analog converters (DACs) and then to the stereo amplifiers.

The whole digital radio process is far more complex than the original analog process. You have to ask, why do this? There are several answers. First, we do it because we can. DSP chips and the related software are as cheap as any analog circuits these days — more complex or not. Second, digital signals have a few really great benefits over analog signals.

For example, digital signals are more immune to noise. While analog FM is generally immune to noise as well, digital is even better. And digital really makes transmissions in the AM band virtually noise free whereas the regular AM signals are always affected by lightning, static, auto ignitions, and any other electromagnetic disturbance that produces some amplitude variation.

Another benefit is that OFDM is very robust in the presence of changing paths of the radio signals. In the VHF FM band, signals are easily reflected and refracted by buildings, water towers, and other things so often the signal takes multiple paths to the receiver resulting in fading and signal cancellation. Just being in a moving vehicle produces multipath effects. The OFDM virtually eliminates the problem.

HD radio produces a sound that is more like playing a CD. The audio frequency response on the FM channels is about the same with both analog and digital, but on AM, the response is greater giving music a far better quality.

One of the neat features of HD radio is that because of the great compression techniques used, stations can actually transmit up to three separate digital audio streams in addition to the legacy analog signal. Called multicasting, this means that one digital channel can parrot the analog channel but you can add two others with a different format — news, sports, or talk instead of music or just country instead of jazz, or whatever. It really multiplies the number of different stations and formats available to you.

Perhaps the greatest reason to go HD, is that it's free. This is in contrast to the digital satellite radio services Sirius and XM that require a subscription. Of course, you do have to have an HD-enabled radio. Still a good deal though, because there are about 1,400 stations transmitting HD signals. Most of them are table-top units, but auto radios — both after-market and pre-installed — are now available. For a list of stations in your area and a summary of radios available, go to the iBiquity website at **www.ibiquity.com**.

■ FIGURE 1. This is the HD100 HD digital radio by Radiosophy of South Dakota. The radio signals are free and with HD, you get more channels than you get on a plain analog AM/FM radio at improved sound quality.

THE RADIOSOPHY RADIO

Radiosophy is an HD radio company in South Dakota. (I'm not kidding, South Dakota!) They make the HD100 shown in Figure 1. It is a basic table-top AM/FM radio with clock and full HD functionality. Its bright blue display with white characters shows everything you need to know including frequency, station call letters, and any data that the station transmits (like song title, artist, etc.).

After you have turned the radio on, select AM or FM with the band button, then tune with the Tune+ and Tune- buttons that increment the phase-locked loop frequency synthesizer in increments corresponding to the AM or FM band layout; 10 kHz for AM and 200 kHz for FM. You can also use the Seek button to scan for any station, HD or otherwise. In the FM mode, the red stereo light will come on if you are receiving stereo. If the station is transmitting HD, the blue HD light comes on flashing until the radio syncs with the signal. Then the blue HD light remains on.

The radio works like any other radio in that you have some preset buttons for your favorite stations. On the HD100, you get five each for AM and FM selections. The big knob in the center is the volume control. The clock is set and used just like any other radio clock. It has all the usual alarm/snooze/sleep modes you are used to.

For best performance, the HD100 comes with two antennas. The FM antenna is a telescoping whip mounted on top of the case. The AM antenna is a separate loop that you need to connect to the two terminals on the rear panel. Many AM radios have built-in antennas and often performance is compromised. With a loop, the signal pickup is far better and you can adjust the loop position for maximum signal because of its directivity. The FM antenna also disconnects so you can attach an external outside antenna for even more improved performance. The connector is a coax F-type.

As for performance, it has been

excellent. In my area (Austin, TX), there are many HD FM stations. Most of them have two or three auxiliary or multicast channels. I was really surprised at this. Given all the multicast options, the HD basically doubled the number of stations in my area. Cool!

As for AM, there were only two with HD. I suspect that will be the case in most areas, but you never know. Check it out for yourself. Incidentally, HD on the FM band is 24/7. On the AM band, HD is only available during daylight hours. The FCC prohibits night time HD broadcasts because of the very long range possible because of skip propagation. It is common for one distant AM station to interfere with another on the same frequency at night. You can still hear the AM long distance, of course.

Quality-wise, the sound is very good for a small radio. I could actually tell the difference between the analog and digital signals. Describing how audio sounds is pretty much like trying to describe how a particular wine tastes or whether vacuum tube audio is better than solid-state audio. Subjective to the max. In my case, the analog is more of a softer or muffled sound while the digital, to me, is a bit more crisp. Greater clarity like you get with a CD or MP3 player. If you are used to those, you will find HD radio to your liking.

Technically, the HD100 uses a standard "can-type" AM/FM tuner. The IFs come out at 455 kHz for AM and 10.7 MHz for FM, as has been the case for decades. The IF is then sent to be digitized by an analog-to-digital converter. Several HD radios use a chip made by Texas Instruments. Referred to as the AFEDRI82001, it uses a 12-bit pipelined A-to-D converter sampling at 80 megasamples per second (MSPS). This chip then filters the digital signal with DSP filters and decimates the signal down to a lower data rate. The outputs are the in-phase (I) and quadrature (Q) signals in digital form needed by the DSP chip to do its FFT.

The DSP is Texas Instruments' TMS320DRI250 digital baseband. It does all the decoding, demodulation, filtering, and other processing stuff that is part of the iBiquity protocol. The digital outputs then go to DACs where the original signals are recovered. The audio power amps — either class AB or class D — drive the two speakers. A separate amplifier is used for the headphone output.

Overall, the HD100 is an excellent buy. I have tested several other HD radios and they are all comparable but I like the sound on this one the best. You can get it directly from Radiosophy at **www.radiosophy.com**.

For a detailed look at more HD radio stuff and a good section on how HD works is available at the iBiquity site mentioned earlier. If you want the real gory details, go to the Texas Instruments website at **www.ti.com** and click on DSP or search for HD radio. Look for HD radio as an option on new cars in the not-too-distant future. Until then, after market HD car radios are available. **NV**

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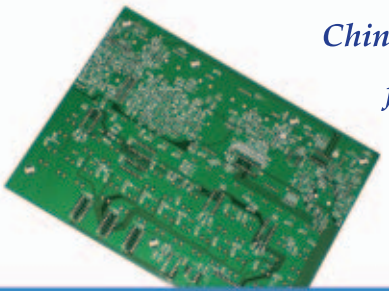

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PIC Development Board

The development board includes a built-in demo application and all the necessary hardware to run each of the example programs included with the SFCLIB (sold separately). It includes sockets for SD/MMC and MicroSD/TransFlash memory cards. The board also has an MPLAB ICD 2 In-Circuit Debugger jack for easy programming and debugging, and a large prototyping area for adding your own circuitry.

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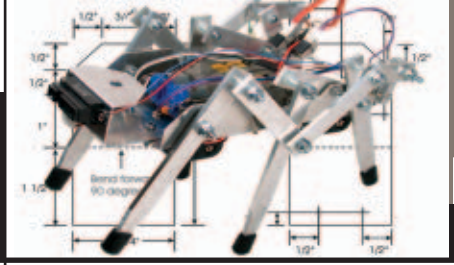

■ GUEST HOSTED BY VERN GRANER

EVOLUTION OF THE BOOGIEBOT MOBILE PLATFORM

MUSIC HAS BEEN A BIG PART OF MY LIFE as far back as I can remember. I've played music in bands, composed and produced music, and (for a short time in the '80s) I even made my living playing in a rock band. One of the constants in my experience with live music is that most performances require a PA system of some kind. And, though a big PA system is wonderful to listen to and perform through, it is a nightmare to load, transport, and assemble!

HEAVY METAL

PA systems are HEAVY. Professional speaker cabinets can weigh hundreds of pounds. Amplifiers have wire wound transformers and steel chassis that make them hefty, as well. Add in mixing boards, lighting equipment, floor monitors, mic and light stands, miles of cables, and you end up with a LOT of weight.

When I was younger, I didn't give a second thought to moving this stuff for each show. Now that I'm a bit older (hopefully wiser?), the idea of schlepping around hundreds of pounds of equipment to perform isn't quite so appealing.

Though no longer a member of a band, I am a member of The Robot Group, Inc. — a 501(3)(c) non-profit corporation in Austin, TX — that, among other things, participates in various community outreach programs. We regularly spend weekends at museums, schools, libraries, Scout meetings, etc., where we show off our creations and try to encourage people to become more involved in robotics, art, and technology.

Though we bring out different displays and equipment, depending on the audience and venue, we almost *always* bring along a PA system. We use it for speaking to the crowd, playing sound to go with our video projector, and to allow us to perform music using the Thereping instruments (detailed in the April '06 issue of *Nuts & Volts*).

Carting all this stuff to and from these events is not the high point of the day for us. As we were loading up after a fairly big performance (Figure 1), I was daydreaming about creating a PA system that could actually unload and load itself. These daydreams are the seeds that would eventually blossom to become "BoogieBot."

■ FIGURE 1. Vern Graner playing the drums while audience members play Therepings.

FIGURE 2

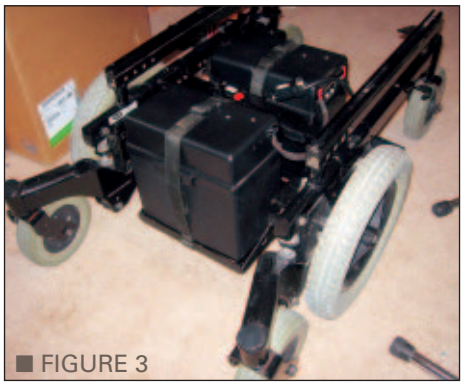
FIGURE 3

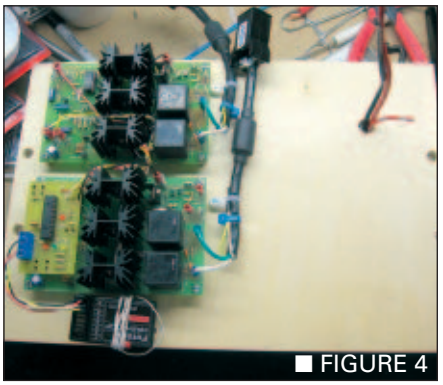
FIGURE 4

But first, I needed a platform.

GET YOUR MOTOR RUNNIN'!

I was lucky enough to receive a salvaged power chair from another member of The Robot Group. It was in pretty rough shape (Figure 2) with the chair portion missing, the fiberglass shell pretty banged up, the speed controller blown, and the batteries in need of replacement. But the motors were still good and the tires were fine.

To rehab the chair, I stripped off the old fiberglass, cleaned the chassis, and removed the old speed controller (Figure 3). I mounted two new MC7 speed controllers and an RCIC2_SC dual channel joystick mixer from Diverse Electronics (Figure 4). The RCIC2_SC mixer allows you to do skid-steer with a single joystick from the R/C receiver.

I found replacement batteries right here in town at **Battery Wholesale.com** that has a store front in Austin so I was able to get the batteries without shipping charges. With new speed controllers, charged batteries, and the Futaba radio in place, I was ready to try out my new mobile platform.

TESTING ... TESTING ... IS THIS THING ON?

I switched on the power for the first time and carefully pushed the joystick forward. The motors made their whirring sounds but the chassis sat stock still. A bit of investigation showed I had not engaged the wheels! Seems this type of power chair has mechanical "free wheeling" levers that need to be placed in the "run" position or the motors don't engage. With the levers in the run position, I again moved the joystick and the chassis slowly rolled across the floor! Success! I then tried running it a bit faster and was pleasantly surprised to find the MC7s made no buzzing noises when PWM'ing the motors. They do have relays that click when the motor direction is changed, but the controllers are otherwise silent.

I thought the refit was complete until a fellow robot group member discovered that the motors on this chair have electric brakes that need to be energized to release them! Once we rigged up the wires to the electric brake leads on the motors, my battery life and top speed improved dramatically. So, now I had a powerful mobile platform but ... what could I do with it?

BREAK IT DOWN!

Because of the diversity in our group membership and the audiences

FIGURE 5

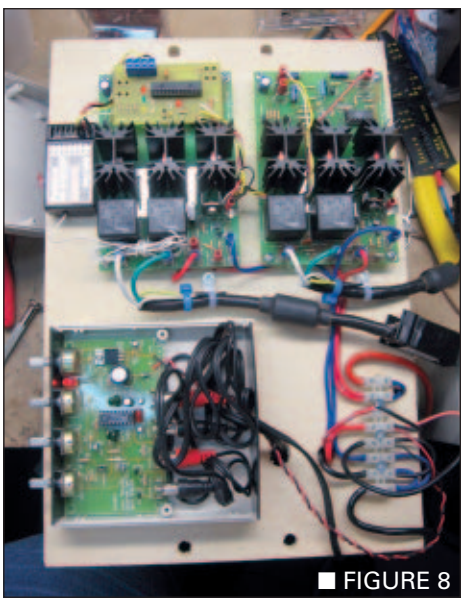
FIGURE 8

FIGURE 6

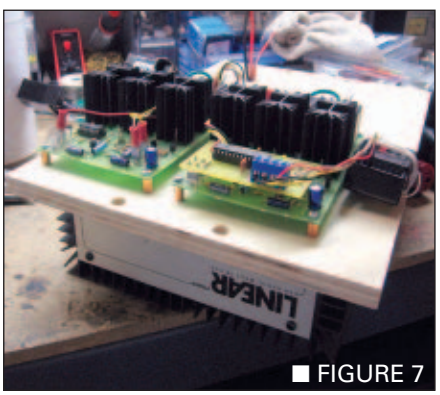

FIGURE 7

■ FIGURE 9

we encounter, there's a surprising amount of gear to be set up and broken down when we do an event (Figure 5). We had a show coming up at the Bob Bullock Texas State History Museum, and I had this new mobile platform ready to go when it hit me (the idea, not the mobile platform). Why not use this new chassis to hold a PA system we could take with us?

I found a suitable piece of wood to use as a base for the speakers and tried it on for size (Figure 6). Now all I needed was an audio amp and some speakers. Since the chassis is powered by dual 12V batteries, I dug out an old 200 watt car audio amp and attached it to the underside of the speed controller board (Figure 7) and then added a small audio preamp kit (Figure 8). I couldn't find a pair of speakers that would easily fit on the wooden top so — in a hurry — I affixed a couple of portable speakers directly on top of the battery cases. Last, I stole ... er, "borrowed" my son's iPod and I had a complete mobile music system ready to go (Figure 9).

AND THE BEAT GOES ON ...

BoogieBot was a big hit at the show, running around blasting music, spinning in circles, shimmying to the beat, and dancing with the kids. The great response has encouraged me to take the platform to the next level. I plan to create some large scale speakers to sit atop the platform and put in larger amplifiers and a sub woofer so it can *really* rock. I'm hoping to use some beefy gearmotors to allow the speaker cabinets to extend/retract Transformers-style and to add more lights and a mirror ball so the BoogieBot can be a mobile dance party.

I'll keep track of my progress with my camera and share my story as it proceeds. For now, you can see more pictures of BoogieBot at the link in the Resources list or, you can drop me an email at vern@txis.com to see how things are going. **NV**

RESOURCES

■ *Diverse Electronics*
www.diverseelectronicservices.com

■ *Battery Wholesale*
www.batterywholesale.com

■ *Bob Bullock Texas State History Museum*
www.thestoryoftexas.com

■ *BoogieBot at Movie Premiere*
www.notepad.org/surfsup

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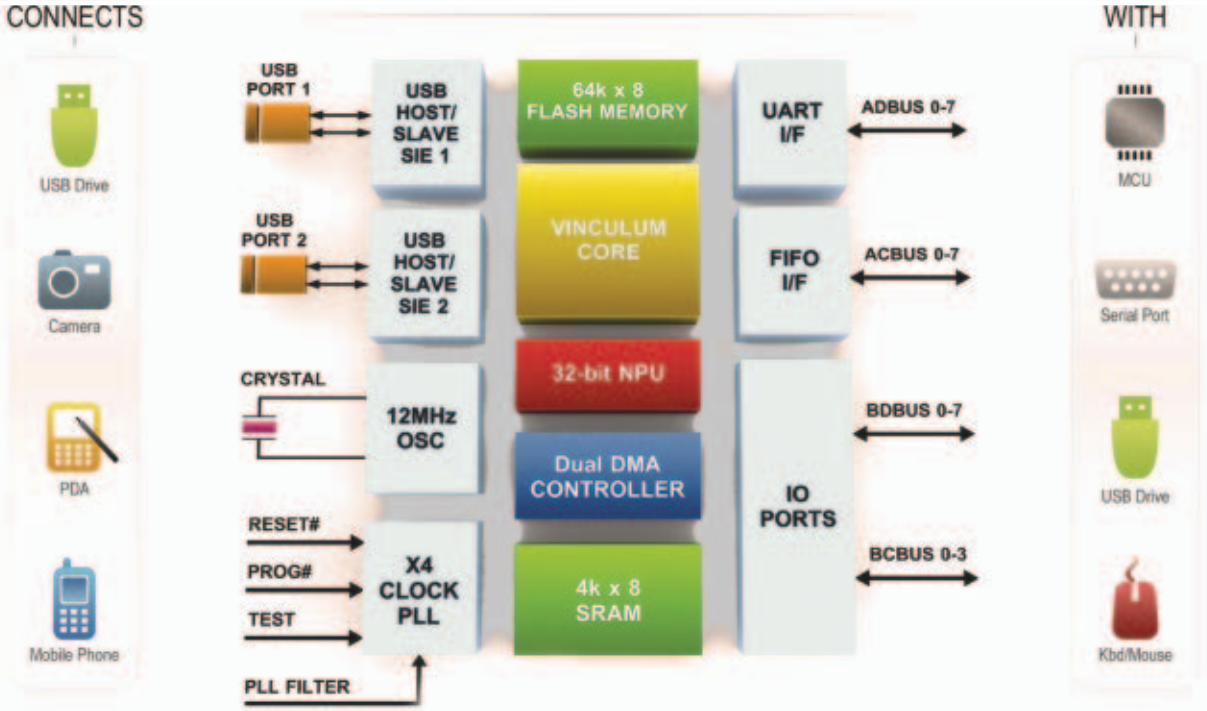

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■ BY CHUCK HELLEBUYCK

PICkit™ 2 STARTER KIT VS. PICkit 2 DEBUG EXPRESS

IF YOU'VE BEEN READING THIS column on a regular basis, you will — no doubt — have realized that I'm always on the lookout for a better and lower-cost starter package, or at least programming solution. I've recommended Microchip Technology's PICkit™ 2 Starter Kit in the past, and have also mentioned its cousin — the PICkit 2 Debug Express. I've received several emails asking me to cover the PICkit 2 Debug Express in more detail, since there is apparently some confusion over which version of the PICkit 2 to buy. What I found out is that the PICkit 2 Starter Kit and PICkit 2 Debug Express are identical, except for the demo board included, so the choice gets much easier to make.

If you visit the Microchip website (**www.microchip.com**) and see both the PICkit 2 Starter Kit (#DV164120) and the PICkit 2 Debug Express (#DV164121), you may notice that they look very similar and they both cost $49.99. They look similar because the programmer/debugger electronics are identical. The hardware is exactly the same with possibly a different firmware level installed. In fact, Microchip makes the firmware free to download, so you can update the firmware version on either package you purchase to the latest identical level.

The software to control the PICkit 2 comes in two varieties: a stand-alone application for programming, and Microchip's MPLAB® Integrated Development Environment (IDE) for programming/debugging. To use it as a programmer or programmer/debugger, choose that through the MPLAB IDE's programmer or debugger menu option (see Figure 1).

Note that earlier I stated "possibly" different firmware levels. The reason I say this is because the firmware level used by the MPLAB interface and the firmware level used by the stand-alone interface were at different release levels. The stand-alone interface doesn't offer debugging, so I assumed the PICkit 2 Debug Express only worked with the MPLAB interface. If you took a PICkit 2 and used it with the stand-alone interface and then later switched to the MPLAB IDE interface, MPLAB IDE would automatically update the firmware. This made me think there was a different firmware used for the PICkit 2 Starter Kit and the PICkit 2 Debug Express, but that was not true. They were just different release levels. All of this was corrected with MPLAB version 7.62, which was just released on the Microchip website as I wrote this column.

Both the stand-alone application and the MPLAB IDE will update the PICkit 2 to identical firmware version 2.10. So, this means that both the PICkit 2 Starter Kit and the PICkit 2 Debug Express are identical, except for the demo board. Deciding which one to buy is simplified down to which demo board you want.

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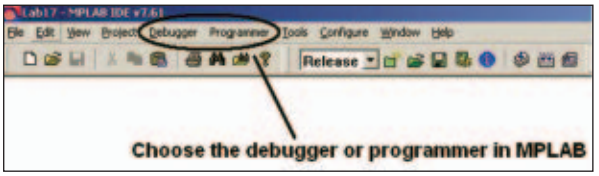


■ FIGURE 1. MPLAB IDE Menu Options.

FIRMWARE

Before I get into the different demo board choices, you may wonder what firmware is. I'm really not sure where the term came from, but firmware is just another term for the software that controls the hardware. The difference is that firmware is written, compiled, and ready to load in the hardware, while software is typically the source code that can be modified or customized for your hardware or application — but then you have to compile it and create the .hex file. In the case of the PICkit 2 Starter Kit and PICkit 2 Debug Express, the hardware is identical and so is the firmware. Updating the operation to

support the latest PIC MCUs just requires a new firmware download.

Many third-party PIC microcontroller (MCU) programmers work this same way. They have a control MCU inside (typically another PIC MCU) that receives the .hex file and then sends it to a socketed, blank PIC MCU to be programmed. The software that runs the programmer's control MCU is called the firmware, and it can be updated as new PIC MCUs are released. This is also how the PICkit 2 microcontroller programmer hardware functions.

At the heart of the PICkit 2 microcontroller programmer is a PIC18F2550, which has the USB drivers built in. The PIC18F2550 uses a bootloader to self program the firmware via its USB port. One of the nice things about the PICkit 2 programmer is that the 5V USB line is passed through to the application, so you can also power your circuit from the PICkit 2 programming connector. You can get the full PICkit 2 microcontroller programmer schematic in the user guide that comes on the included CD, or you can download it from the **microchip.com/PICkit** website.

PICKIT 2 STARTER KIT

So, why are there two different starter packages, if they both come with the same programmer/debugger? Since the PICkit 2 Starter Kit and the PICkit 2 Debug Express use the same interface, Microchip just made it convenient by selling two variations of the demo board — to make it either a programmer or a programmer/debugger, right out of the box. Because of this commonality, it makes sense that some beginners or even experienced users might wonder which unit to purchase. It really depends on what you plan to do with it.

If you just want to use the 20-pin, 14-pin, and eight-pin PIC MCUs, then the PICkit 2 Starter Kit for $49.99 is the way to go (see Figure 2). The included PICkit 2 low pin count demo Board has a 20-pin socket and several simple components already soldered to the board — including LEDs, a potentiometer, and a momentary switch. The 20-, 14-, and eight-pin PIC MCUs all share the same programming connections on the top eight pins, so the 20-pin socket accepts all three package sizes for programming. The PICkit 2 Starter Kit also includes a PIC16F690 to get you started.

■ FIGURE 2. PICkit 2 Starter Kit.

The PICkit 2 Starter Kit is listed as part number DV164120, and can be ordered directly from **www.microchipdirect.com**. This is clearly a great choice if you just want to write code and then program. The problem arises when you decide you want to use the MPLAB IDE debugging feature, which allows you to single step through your code, run in animate mode, or run to a breakpoint.

The 20-, 14-, and eight-pin PIC MCUs do not have the debug executive silicon inside, because of the die size limitations. To debug with these parts, you need an adapter (Figure 3) that matches the part you want to debug. The adapter has a custom chip with the debug executive, and the rest of the chip consists of "normal" silicon in a larger package with extra pins for the debugger connection — so you can debug code for these smaller PIC MCUs. This adds more cost, but the adapters are only around $25-$35.

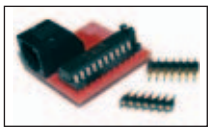
So, this leads us to the PICkit 2 Debug Express. If you really want to debug your code and you are using a PIC MCU with the debug silicon on it (which includes almost every 18-, 28-, 40-pin, and larger PIC MCU), then you might want to consider using the PICkit 2 Debug Express.

PICKIT 2 DEBUG EXPRESS

The PICkit 2 Debug Express is the better choice to start with, if you are just learning about PIC MCUs or are developing a design that needs a lot of I/O. The PICkit 2 Debug Express comes with a development board that has a 44-pin, surface-mount PIC16F887 soldered to it. The PIC16F887 is a great part for development, because it has most of the popular features designers want in their PIC MCUs; and it has the debug executive silicon built in, so it can be debugged in-circuit.

■ FIGURE 4. PICkit 2 Debug Express.

■ FIGURE 3. Debug Adapter.



As I've discussed in previous articles, a debugger lets you run your code in animate mode, single step, or run to a set breakpoint. This can be quite handy when you get into bigger programs that are hard to follow.

Sometimes a simple typo can be accepted by the compiler as a good command, but it's doing something different than what you expect. That type of error can be difficult to find without a debugger helping you to narrow the search. That is really what a debugger does for you. You can set a breakpoint just above the section of code that you know isn't working properly. Then, after the breakpoint you can single step through the code to see where the operation may be running off track.

Microchip also offers the MPLAB ICD2 debugger, which supports all of the PIC MCU families. However, the MPLAB ICD 2 module (#DV164005) costs $159.99, so the PICkit 2 Debug Express is a lower-cost alternative in a very small package. Figure 4 shows the PICkit 2 Debug Express.

The PICkit 2 in debug mode previously did not support many parts for debugging, but that changes with the release of MPLAB IDE version 7.62. Most of the PIC16F and PIC18F

■ FIGURE 5. Chuck's Custom Starter Package.

MCUs with the debug executive are supported in this version.

One of the limitations of the PICkit 2 Debug Express is the surface-mount design of its included demo board. Because the PIC16F887 is surface-mounted to the demo board, this package is not the best option if you want to program another PIC16F887 by plugging a blank part into a socket. This makes the PICkit 2 Debug Express a little less useful to the hobbyist.

So, if you want a programmer/debugger that comes with a demo board sporting a DIP socket that accepts PIC MCUs that have the debug executive silicon, then I have another option for you.

MY CHOICE

Microchip offers several different PICkit 2 demo boards separately that plug right into the PICkit 2 microcontroller programmer. You can even buy different versions of the demo boards, in addition to the ones included with the starter packages. These extra boards are sold in packs of three, with one of the three populated just like the starter kit board and two more that are completely blank — ready for you to solder onto your own design.

One of the demo boards offered by Microchip has a 28-pin DIP socket and includes a PIC16F886 on the completed board. This PICkit 2 28-pin demo board (#DM164120-3) is actually part of Microchip's PICkit serial analyzer, which I will save for another article.

The reason I mention this demo board is because it fits the format I described above. The board will accept any 28-pin PIC MCU in a 0.300 wide DIP package, and has the PICkit 2 programming/debugging header for plugging into the PICkit 2 microcontroller programmer. This opens up lots of opportunities.

As you know, I focus on the Basic language for many of this column's projects because it's an easy language for the beginner to use. If you want to start with Basic, then my idea is to create your own custom starter package by first buying the stand-alone PICkit 2 microcontroller programmer, for $34.99. This saves a little money to purchase the demo board of your choice.

The USB cable comes with the programmer and all of the starter kit software is on the included CD. The PICkit 2 microcontroller programmer alone can be purchased under the part number PG164120.

The PICkit 2 28-pin demo board can be purchased at the same time under the part number DM164120-3 for $24.99. The reason this combination works best for the Basic programmer is because the PICkit 2 28-pin demo board (see Figure 5) can accept a PIC16F876A. Then, you can use the free sample version of microEngineering Labs' PICBASIC PRO compiler which supports the PIC16F876A to create your code. (You can download the sample version from **melabs.com**.)

The sample version of the PIC BASIC PRO compiler can also be run in Microchip's MPLAB IDE, which comes on the PICkit 2 CD or can be downloaded for free from Microchip's website. More information on how to set this up is at: **melabs.com/support/mplab.htm**. Using this PICBASIC PRO compiler within the MPLAB IDE provides all of the debugging features, plus the one-touch compile and program features of the MPLAB IDE/PICkit 2 setup.

There is a catch to my custom setup, though. You will have to add a crystal or resonator to the board, since the PIC16F886 doesn't need an external oscillator but the PIC16F876A does. I suggest that you use a three-pin SIP socket, so you can plug in various crystal/resonator speeds. The development board traces are already designed to accept an external crystal/resonator, so this modification is easy for the beginner to accomplish.

The total cost of this custom setup is $59.98 or about $10 more than the standard starter packages (but you also get two blank PICkit 2 28-pin demo boards for future designs to justify the extra $10).

To use the PIC16F876A in debug mode, you'll need MPLAB 7.61 or later. Hopefully, this version or later will be on the included CD — but if an earlier version of the MPLAB IDE is included, you can download the latest version of the MPLAB IDE for free from **microchip.com/mplab**.

To summarize my recommendations, you can use the sample version of the PICBASIC PRO compiler and compile, program, or debug from within the MPLAB IDE — using the PICkit 2 microcontroller programmer in programmer mode or programmer/debugger mode. You can then program more blank 28-pin DIP packaged PIC MCUs as you create more projects with this great starter package. Getting all this for $58.98 (plus tax and shipping) seems like a great deal to me.

MORE OPTIONS

Now, it doesn't stop there. If you read last month's column, you also might remember that I mentioned Jack Smith's book *Programming the PIC Microcontroller with MBasic*, which includes a full working version of Basic Micro's MBasic Professional compiler — limited to compiling the PIC16F876 or PIC16F876A. MBasic will not run within the MPLAB IDE, but you can still use the PICkit 2 microcontroller programmer with the MBasic Professional compiler by interfacing the stand-alone version of the PICkit 2 PC software for programming PIC MCUs outside of the MPLAB IDE.

You do that by simply importing the .hex file generated by the MBasic Pro compiler from Jack's book into the PICkit 2 software. This is another low-cost option for the hobbyist to get started with programming PIC MCUs. (For *Nuts & Volts* subscribers, if you order Jack's book through the *N&V* store during the month of October, you'll get free shipping within the US. Price of the book is $62.95 — which is actually cheaper than a full-featured compiler. Call *N&V* to order at 1-800-783-4624.)

PICBASIC PRO

If you do choose to use PICBASIC PRO, after you get comfortable with the PICBASIC PRO sample version, you might be ready to shell out the $250 for the full PICBASIC PRO. This will give you the ability to program the other 28-pin PIC MCUs, such as the PIC16F886 or even some of the 28-pin PIC18F parts – which also plug into the 28-pin board.

The full version of PICBASIC PRO supports most of the eight-bit PIC MCUs from the small PIC10F family, up to the high-performance PIC18F family. Later, you can add the 20-pin development board to your collection and program the 20-, 14-, and eight-pin PIC MCUs with PICBASIC PRO, as those are also supported.

You can even prove out your design with a 28-pin part using the debugger and then recompile it for a smaller part using the programmer and the 20-pin board. I've successfully done this, but you really have to understand the differences between the two parts to do this properly.

I'm sure new demo boards will be released in the future, because the PICkit 2 microcontroller programmer is handy to use now. I have heard about a few third-party boards that are also in the works for the programmer. If Basic is not your language of choice and you prefer to program in C, the HI-TECH PICC-Lite compiler is also included on the PICkit 2 CD. Unfortunately, the PICC-Lite compiler doesn't support any 28-pin PIC MCU parts.

It does support several smaller parts that fit the 20-, 14-, or eight-pin packages. The PICC-Lite compiler also supports the PIC16F887, which is the surface-mount development board part. The PICC-Lite compiler can be run inside the MPLAB IDE, so you get a professional style setup for a very low price. CCS' PCM Midrange C Compiler Demo for the PIC16F887 is also now part of the software included on the PICkit 2 CD to give you another choice.

The sample versions of the various compilers I mentioned don't support the PIC18F parts, but you're in luck here, as well. Microchip does offer a student version of their MPLAB C18 compiler, which you can download for free at **microchip.com/c18**. The only limitation of this free version is that the compiler loses some optimizations after 60 days, but that's not a big deal for most beginners. Besides, this compiler supports all of the PIC18F MCUs. This is another option for the beginner interested in C programming, and this will work with my makeshift 28-pin starter package idea.

CONCLUSION

I hope this wasn't too confusing, and that I successfully clarified the differences between the two PICkit 2 starter packages for you. I added a PICkit 2 header to my Ultimate OEM board that has a 28-pin socket to see how well it would work. I was extremely happy with the setup, since I now have a great connection between the MPLAB IDE and my breadboard module's development setup. This allows me to do just what I described above, without having to buy the PICkit 2 28-pin demo board. It works great.

I recommend that you make your own starter package with a PICkit 2 microcontroller programmer, a PICkit 2 28-pin demo board, a sample version of the PICBASIC PRO complier, and Microchip's free MPLAB IDE, to get started in programming PIC MCUs. You'll also have a tool set that can grow with your programming skills, without breaking the bank account. Programming PIC MCUs just gets better and better, doesn't it? **NV**

CONTACT THE AUTHOR

■ Chuck Hellebuyck can be reached at chuck@elproducts.com

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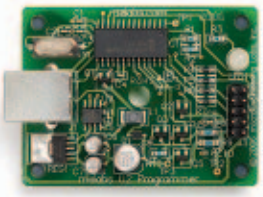

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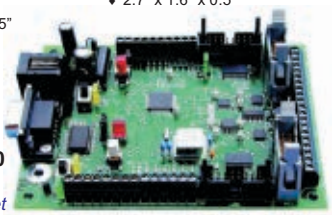

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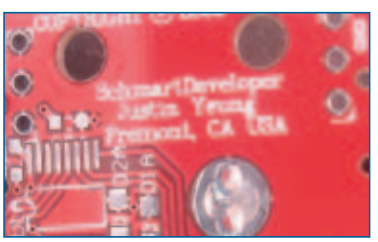

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READER FEEDBACK

Continued from page 8

are X band but there are some in the K regions also. Even 10 years ago, when I was responsible for the maintenance and repair of the door openers at the hospital where I work, they were all radar. I would also question the reliability of PIR detectors used to scan outside areas as they are affected by factors such as wind and other weather phenomena. On the other hand, the Doppler shift radar detectors work well in this application.

By the way, love your magazine! You have come up with a great balance between the old analog and digital discreet designs and the new PIC projects. I am an old discreet designer/builder who is learning to love the new PICs, especially the PICAXE due to its ease of programming and low cost. Keep up the good work!

Ron Bean

PUT A (HEAT) TAPE ON IT

About thawing frozen pipes ... there is a better way to thaw them and to keep them from freezing again. There is a product available called heat tape. It looks like a roll of 12 ga romex wire except that it's a heating element with a temperature sensor in it and a plug or direct connect, depending on the model purchased. This wire is wrapped around the exposed piping and then covered with an insulation sleeve and connected to standard power.

When the enclosed sensor detects falling temps in the correct range, it starts heating the pipes to prevent freezing; the insulating sleeve keeps the heat in and helps keep the energy use low. I have used these wraps with great success. It's a lot less expensive than paying to have the frozen pipes thawed and the burst pipes replaced, not to mention the water damage after the pipes burst. By the way, if you are a renter, when you leave you can take the wire with you; if it's a plug-in type, it's not considered a permanent item so you don't have to leave it if your landlord won't pay for it.

The following website gives an excellent tutorial on the proper use and installation of pipe heat tape including several safety precautions: **www.mygreathome.com/fix-it_guide/heat_tape.htm**.

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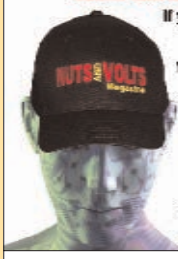

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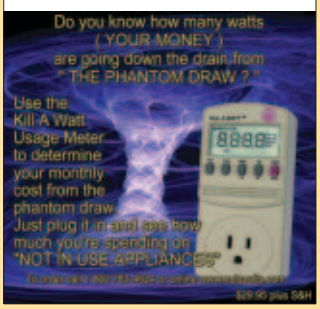

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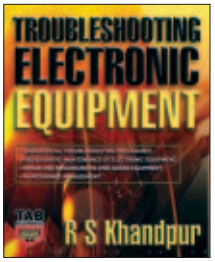

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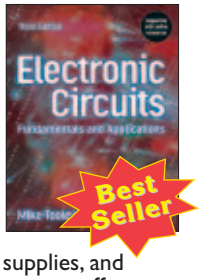

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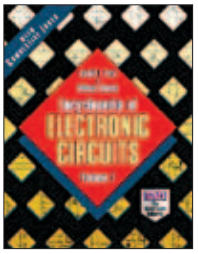

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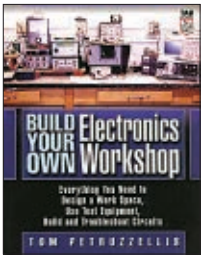

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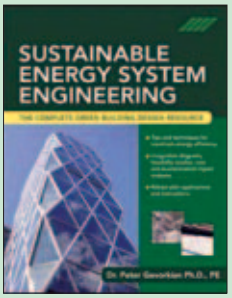
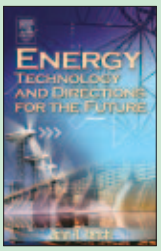
GREEN POWER ENERGY

Sustainable Energy System Engineering
by Peter Gevorkian
Publish Date: October 10, 2006



Create more efficient energy systems for any building project. Offering nuts-and-bolts direction on a wide variety of project types including residential, roof, and ground-mount systems, solar power farms, and large commercial solar power installations — Sustainable Energy System Engineering delivers the insight you need to produce wiring plans, calculations, and systems integration. **$99.95***

Energy Technology and Directions for the Future
by John R. Fanchi
Publish Date: January 26, 2004

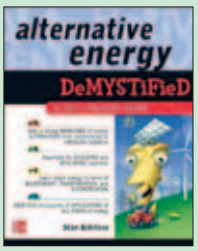


This book presents the fundamentals of energy for scientists and engineers. It is a survey of energy sources that will be available for use in the 21st century energy mix. The reader will learn about the history and science of several energy sources, as well as the technology and social significance of energy. Themes in the book include thermodynamics, electricity distribution, geothermal energy, fossil fuels, solar energy, nuclear energy, alternate energy (wind, water, biomass), energy and society, energy and the environment, sustainable development, the hydrogen economy, and energy forecasting. **72.95***

Solar Energy Projects for the Evil Genius
by Gavin D. J. Harper
Publish Date: June 22, 2007

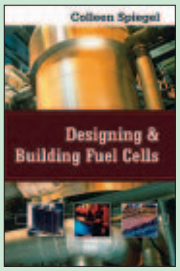
Let the sun shine on your evil side — and have a wicked amount of fun on your way to becoming a solar energy master! In *Solar Energy Projects for the Evil Genius*, high-tech guru Gavin Harper gives you everything you need to build more than 50 thrilling solar energy projects. You'll find complete, easy-to-follow plans, with clear diagrams and schematics, so you know exactly what's involved before you begin. **$24.95**

Alternative Energy Demystified
by Stan Gibilisco
Publish Date: October 23, 2006



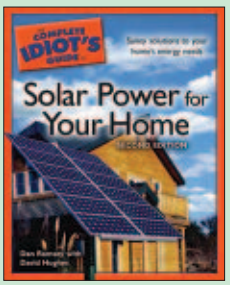
The fast and easy way to get up-to-speed on alternative energy. Because of current events, geopolitics, and natural disasters, the cost of fuel is front and center in our lives. This book provides a concise look at all forms of energy, including fossil fuels, electric, solar, biodiesel, nuclear, hydroelectric, wind, and renewable fuel cells. You will get explanations, definitions, and analysis of each alternative energy source from a technological point-of-view. **$19.95**

Designing & Building Fuel Cells
by Colleen Spiegel



Designing & Building Fuel Cells equips you with a hands-on guide for the design, modeling, and construction of fuel cells that perform as well or better than some of the best fuel cells on the market today. Filled with over 120 illustrations and schematics of fuel cells and components, this "one-stop" guide covers fuel cell applications, fuels and the hydrogen economy, fuel cell chemistry, thermodynamics and electrochemistry, fuel cell modeling, materials, and system design, fuel types, delivery, processing, and much more. **$89.95***

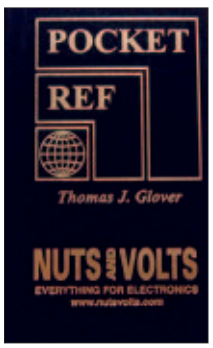
The Complete Idiot's Guide to Solar Power for Your Home
by Dan Ramsey / David Hughes
Publish Date: May 2007



The perfect source for solar power — fully illustrated. This book helps readers understand the basics of solar power and other renewable energy sources, explore whether solar power makes sense for them, what their options are, and what's involved with installing various on- and off-grid systems. **$18.95**

MUST HAVE

Pocket Ref
by Thomas J. Glover



This great little book is a concise, all-purpose reference featuring hundreds of tables, maps, formulas, constants, and conversions. AND it still fits in your shirt pocket! Goes where you go! **$12.95**

New To Our Store

The Pocket Idiot's Guide to the iPhone
by Brown, Damon
Publish Date: August 7, 2007

See what this new technology can do for you. *The Pocket Idiot's Guide to the iPhone* is a quick reference guide that includes troubleshooting info and helpful tips for the non-geeky iPhone owner. *This could be helpful for those on the fence about purchasing, as well.* **$9.95**

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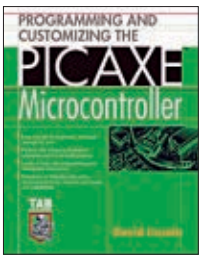
MICROCONTROLLERS

Programming the PIC Microcontroller with MBASIC
by Jack Smith

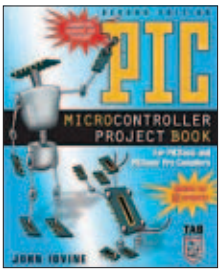
No microcontroller is of any use without software to make it perform useful functions. This comprehensive reference focuses on designing with Microchip's mid-range PIC line using MBASIC, a powerful but easy to learn programming language. It illustrates MBASIC's abilities through a series of design examples, beginning with simple PIC-based projects and proceeding through more advanced designs. **$62.95***

Programming and Customizing the PICAXE Microcontroller
by David Lincoln



Here's everything you need to harness the power of PICAXE, the inexpensive yet versatile chip that's taken the electronics community by storm. This beginner-friendly guide from IT pro and PICAXE expert David Lincoln shows you just what Revolution Education's PICAXE can do — and helps you make it do it! Packed with ready-to-build projects for all the flavors of PICAXE. **$39.95**

PIC Microcontroller Project Book
by John Iovine



The PIC microcontroller is enormously popular both in the US and abroad. The electronics hobbyist market has become more sophisticated. This new edition is fully updated and revised to include detailed directions on using both versions of the microcontroller, with no-nonsense recommendations on which is better served in different situations. **$29.95**

BACK ROOM

BOOK BLOWOUT SPECIAL

PICmicro Microcontroller Pocket Reference
by Myke Predko

Designed to complement *Programming & Customizing the PICMICRO*, this book contains a minimum of verbiage and serves as an immediate device, code, and circuit lookup for experienced PICMICRO applications designers.

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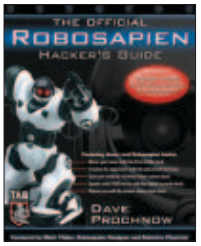
BACK ROOM

The Official Robosapien Hacker's Guide
by Dave Prochnow
Publish Date: August 17, 2005



The Robosapien robot was one of the most popular hobbyist gifts of the 2004 holiday season. The brief manual accompanying the robot covered only basic movements and maneuvers — the robot's real power and potential remain undiscovered by most owners — until now! This timely book covers all the possible design additions, programming possibilities, and "hacks" not found any place else.

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PROJECTS

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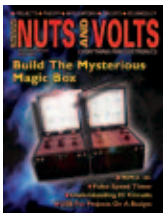
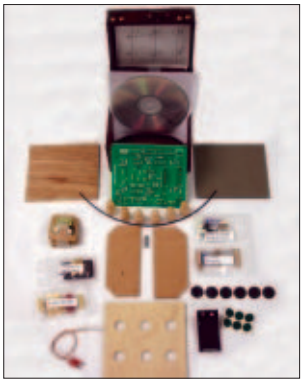


As seen in our April issue.

We received such great reviews on this magic box kit that we decided to offer it in our store.



This unique DIY construction project blends electronics technology with carefully planned handcraftsmanship. Its delightful innovation will surely amuse you. More importantly though, it bewilders, baffles, and mystifies those observing this subtle magic trick.

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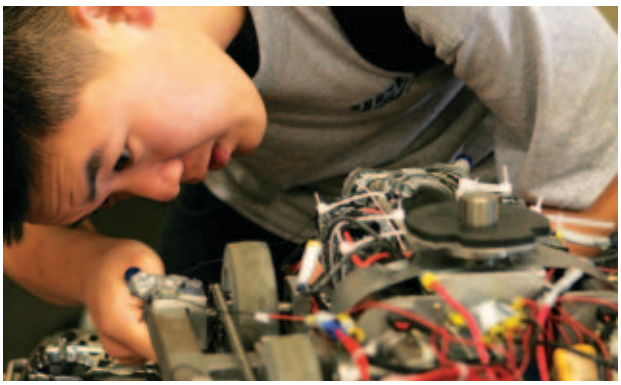

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TECH FORUM

This is a READER-TO-READER Column.

All questions *AND* answers are submitted by *Nuts & Volts* readers and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. Questions are subject to editing and will be published on a space available basis if deemed suitable by the publisher. Answers are submitted by readers and NO GUARANTEES WHATSOEVER are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

All questions and answers should be sent by email to forum@nutsvolts.com All *diagrams should be computer generated and sent with your submission as an attachment.*

QUESTIONS

To be considered, all questions should relate to one or more of the following:

❶ Circuit Design
❷ Electronic Theory
❸ Problem Solving
❹ Other Similar Topics

■ Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
■ Include your Name, Address, Phone Number, and email. Only your Name, City, and State will be published with the question, but we may need to contact you.
■ No questions will be accepted that offer equipment for sale or equipment wanted to buy.
■ Selected questions will be printed one time on a space available basis.
■ Questions are subject to editing.

ANSWERS

■ Include in the subject line of your email, the question number that appears directly below the question you are responding to.
■ Payment of $25.00 will be sent if your answer is printed. Be sure to include your mailing address or we cannot send payment.
■ Only your Name, City, and State, will be printed, unless you say otherwise. If you want your email address included, indicate to that effect.
■ Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

>>> QUESTIONS

I work in a hot, one man fabrication shop. I have a furnace type squirrel cage fan blowing at my workbench to cool me down. I'd like to have the fan on a turn table and rotate toward me no matter where I go in the shop. I'd have to wear a transmitter or sensor of some sort. I guess there'd be a stepper motor in there somewhere, too. Azimuth tracking comes to mind. Is there anything out there like that?

#10071 Rod Reynolds
via email

I am looking for a high brightness LED with a peak wavelength around 680 nm. Is there anything similar to the offerings from Cree, Seoul, Philips, etc.?

#10072 Benjamin Butler
Boston, MA

I often drive my motorcycle late at night while traffic is light. There are many traffic signals where the vehicle detection device doesn't see my bike because there is not enough iron in it to trigger the inductive loop. I have to either run the light or turn right on red.

Is there a circuit capable of generating a signal that could trigger the inductive loop detector? It needs to be 12 volts and ideally low powered so that I can wire it directly into the brake light. This will also give me the ability to pulse the circuit if necessary.

Permanent magnets don't work. I even went so far as to put a row of very strong magnets on the kickstand. I then put the kickstand down directly on the grooves in the pavement where the inductive loop was buried. It never detected my 500 pound Honda.

#10073 Joe Schram
Baker, LA

I have been using the serial port of my PC and languages such as assembly, C++, Java, and VB to communicate with custom designed circuits. Nowadays, all PCs have replaced the serial port with multiple USB ports. I want to migrate my applications but have found working with USB rather difficult. Could someone please suggest a way to send/receive a simple 1-0 digital signal using any programming language (preferably Java)?

#10074 Sahand N.
via email

I have an irrigation system with a HARDY RainDial, six zone controller, by Irritrol. It has only four wires plus a ground going to it and the valve box. It would be impossible to run new or additional wire as the wiring goes under a concrete floor.

Four zones are being used. I recently added a fifth battery-operated zone, but it's a problem as the

batteries tend to wear out. I want to use the controller for timing zone five and would appreciate a circuit that could do this.

The controller outputs 28 VAC as measured at the zone outputs, but by the time it reaches the valve box, it drops by 3V. The ideal solution would be to have an encoder/decoder circuit that would work directly off of the controller. I can then give the fourth and fifth valves different addresses so they could share one line. The draw is about 250 mA at 24-26 VAC for 15 minutes per day.

An alternate approach might be to use the ground as the fifth wire and ground the control box to a copper pipe. However, it is plastic pipe in the ground that goes to the valve box. If I simply drive in a ground rod at the control box for my ground, will this solution work as well?

It would be impossible to get AC electric out to the valve box. If I used the second approach, a possibility exists that I can tie in the main house ground.

#10075 **Howard Epstein**
via email

>>> ANSWERS

[#6076 - June 2007]

Is the new Microsoft operating system Vista back compatible? I have many programs on Astronomy from Windows 98 vintage, on floppies, that cannot be duplicated.

Vista is back compatible. To run the files in compatibility mode, right click on the files and click properties. Next click on the compatibility tab. Check the box before "Run this

[#7071 - July 2007]

I want to run a 24 VAC camera off of a 12 VDC battery. It is rated 6W at 24 VAC.

#1 The camera will also run off of a DC voltage, as the camera's internal rectifier and filter convert the AC voltage to a DC voltage.

The equivalent DC voltage is calculated as follows:

24VACrms x 1.414 = 34Vdc, round up to **36V (Vout)** to compensate for the diode drops.

The current required is 6W/34Vdc = 166 mA, round up to **200 mA (Iout)**.

Vin = 12Vdc, Min.= **10V** Max = **14V**

Now that we have our requirements, we need to boost the 12 volt battery to 34V.

The easiest way is to use National Semiconductor's Power WEBENCH software, which can be found at **www.national.com**. It's free to use!

Inputting the **Vin**, **Vout**, and **Iout** parameters will bring up a list of components for Boost and Flyback converter topologies. The easiest one is the LM2586 Simple Switcher in the Boost configuration.

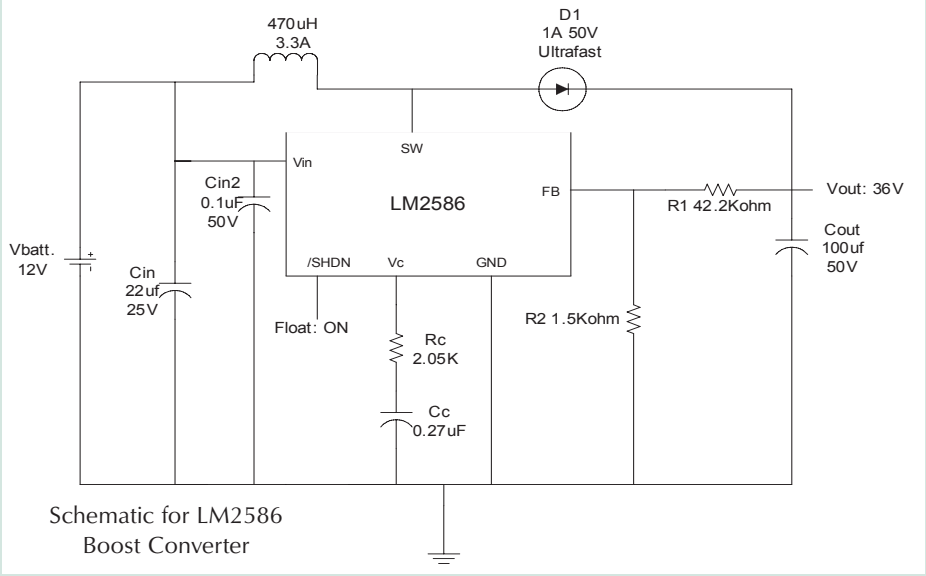
Note: When a boost regulator is shut down, the input voltage will appear at the output. If this is not desirable, add a switch in series with the battery.

WEBENCH will provide the schematic, bill of materials, and provide circuit and thermal analysis.

You will also be able to get up to five free samples of the LM2586-ADJ, or you can purchase an unassembled custom kit at a reasonable price.

The resistor values can use the standard 5% tolerance, as the voltage requirements are not critical. R1 = 43K ohm, Rc = 2.0K ohm

Cin1:22 µF 25V ESR:<1ohm
Cin2: 0.1 µF 50V ceramic
Cc: 0.27 µF 50V ceramic
Cout: 100 µF 50V ESR:< 340 milliohms
D: 1A 50V Ultra-fast Diodes, Inc., B180-13 or equivalent
L: 470 µH 3.3A DCR< 0.12 ohms JW Miller PM2120-471K or equivalent
R1: 42.2K ohm
R2: 1.5K ohm
Rc: 2.05K ohms
IC1: LM2586-ADJ



Schematic for LM2586 Boost Converter

Larry Virgilio
Lake Zurich, IL

#2 The "easiest" way would be to get a very inexpensive 12 VDC to 120 VAC inverter which are available almost everywhere ($20-$25). About the smallest is 50 watts. (You can use it for other things, too.) Then get a 24 VAC transformer and run off it for your camera supply; 24 VAC control transformers can usually be scrounged off old central HVAC units which are also everywhere. Or, if all else fails, RadioShack has them for about $7.

Rod Hogg
REVCOM Electronics
Scott City, KS

program in compatibility mode for:" Finally, select Windows 98 out of the drop-down box, and click OK.

Matthias Kersten
Bull Valley, IL

[#7077 - July 2007]

I need info on where to buy or how to build a cheap mono preamp for my banjo. I need more drive into my amp.

#1 Velleman offers a kit-form preamp, Model K1803; 40 db gain with level pot.

One source is MCM Electronics (**www.mcmelectronics.com**). You will need about 12V/10 mA to run it. I have used several; works good.

Rod Hogg
Scott City, KS

#2 The best and cheapest preamp I've found is in those cheap portable cassette players. You can get them new for under $10 but you can find them in thrift stores for a couple of bucks or less. The cassette mechanisms are typically the broken part, but the amps are usually always good. You get a case with a battery holder and a volume control, and a

[#7075 - July 2007]

Can someone recommend a 12-14 volt circuit which will give a three second duration "high" output of around 5-6 volts (not critical) after 12-14 volts power has been applied to the input for 15 minutes? The "high" output will last three seconds (to activate a very small relay or transistor) and then go back low for 15 minutes over and over.

#1 The illustrious 555 timer comes to the rescue! This circuit (**Figure 1**) will give a "high" output (connecting it to Vcc) for three seconds. If you'd rather have a "low" output (to ground), just remove the diode and flip the resistors around.

I built this circuit and got about 17 minutes off and three seconds on using 5% tolerance resistors and a 20% capacitor. The value of the components was easily achieved using free software from **www.schematica.com**. Better accuracy can be found by adding a trimpot in series with the resistor you are aiming to adjust. (Raising the R1 value will increase the high time, and increasing the R2 value will increase the low time.)

You may not need a relay or transistor on the output as the 555 can deliver 200 mA in either direction. The 555 timer can easily be powered by your 12-14V requirement. The datasheet for the National Semi part says she can take 4.5-16V.

Brian German
Thief River Falls, MN

#2 You have not indicated how accurate or how stable you need the timing. The easy solution is to find two relay timers and have them trigger each other. Plug-in timers can be found in the surplus market and require the least amount of construction to use. These are often found in older traffic lights and industrial controls, but may not work from 12 VDC. Try eBay or here: **www.electronicsurplus.com/ccc2080-time-delay-relays.htm**.

Another solution would be to construct two timers using a timer chip such as the LM555 (or the dual LM556), again setting each to trigger from the other and form an oscillator with 15 minutes delay from one and a three second delay from the other. Google "555 timer" — there's literally more than one million hits!

A better (more reliable, accurate, repeatable) solution is to digitally count down an oscillator that marks sub-times of your desired delays. Fifteen minutes is 900 seconds, so a one second clock followed by a divide-by-900 counter chain would work. An easier solution is to count to 1024 (10 binary stages) of 1024/900 (or 1.138Hz) followed by three more stages to give 3.4 seconds for the output pulse to drive your relay.

The CD4060 IC is a combination oscillator and 14 stage counter that can be operated at a 1.14 Hz clock with a 10 µF cap and 51K resistor (expect a 10% or worse tolerance with garden variety caps; a tantalum cap would be better). The resulting 900 second pulse from the tenth stage could be capacitor differentiated (to get a three second pulse) and drive a transistor switch that, in turn, drives your relay. For a more accurate output pulse, use a second digital counter (CD4013, for example) that counts three periods of the same clock (3.4 seconds duration). The second IC would also feed the transistor driving the relay, both CMOS logic parts and the transistor stage can be operated directly from 12V DC, simplifying the project.

Peter J Stonard
Campbell, CA

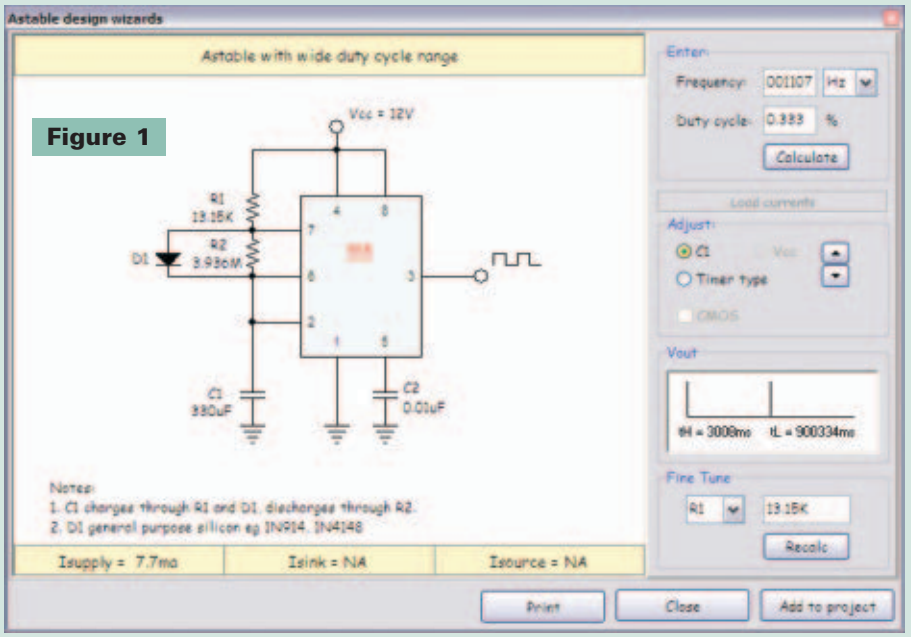


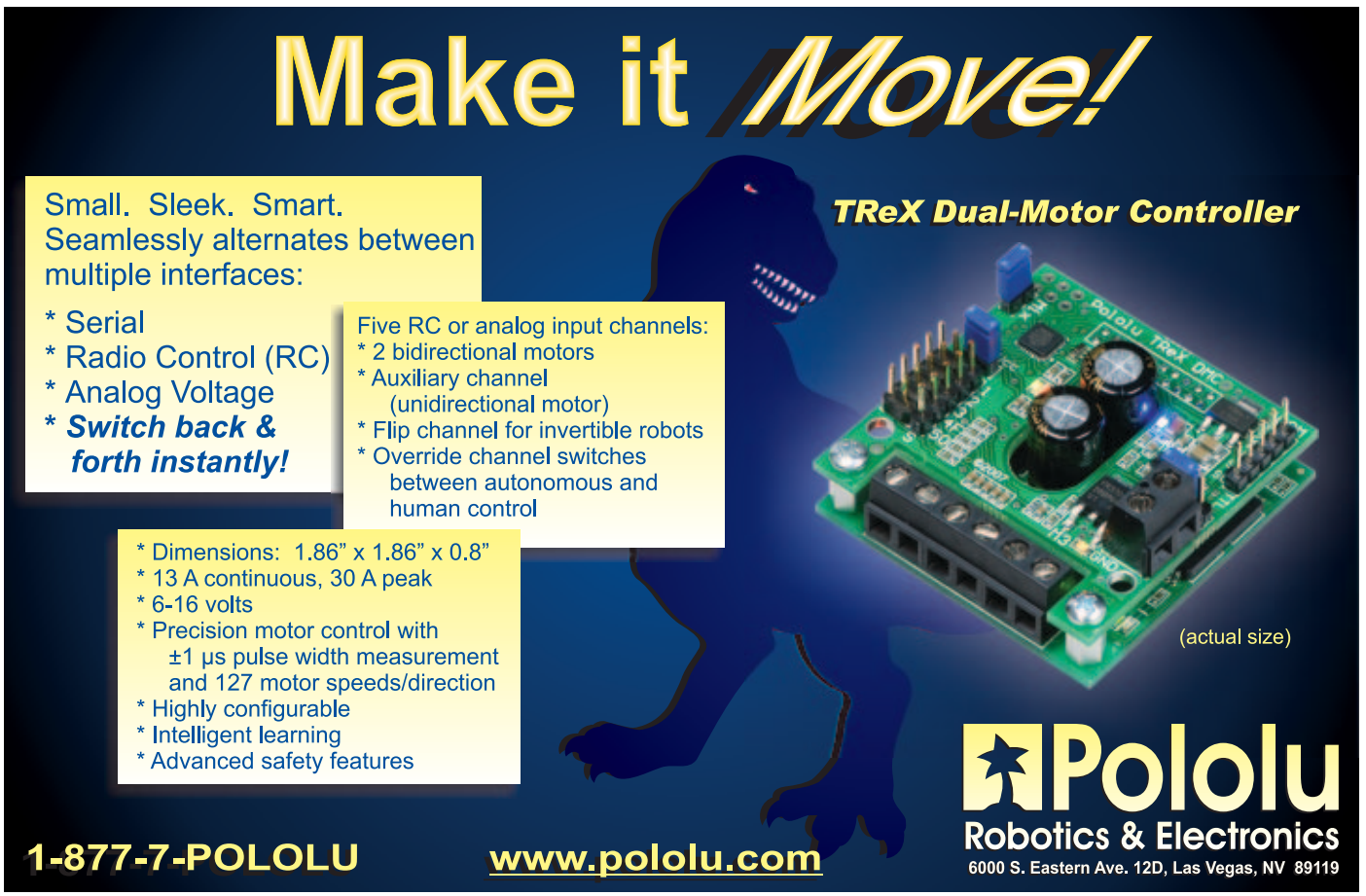
Figure 1

good clean stereo amp capable of driving a good set of headphones or feed into an amp. Just cut the wires off that go to the cassette playback head and install a connector of your choice to the PC board at the same location. Hook the inputs together if you want mono. I have used 1/4 inch female guitar plug connectors and they work fine. Use shielded cable and epoxy the connector to the case. I found these things cheap and fun to play around with. I even thought of using a bunch of them to make a tape loop sound effects device. Maybe someday.

Anonymous

#3 Try **www.apogeekits.com/guitar_preamp.htm**.

Peter J Stonard
Campbell, CA



IN THE SPOTLIGHT

An Interview with Johan Smit

President of Electronics 123

by Marvin Mallon

This month's spotlight is on Electronics 123 whose headquarters is in Columbiana — a town of about 6,000 population located 78 miles southeast of Cleveland on the eastern edge of Ohio. President and CEO, Johan Smit, founded this privately owned, Internet-based company in 1997. He first worked as a chartered accountant in South Africa, which is the equivalent of a CPA in America. He then started a mail order business in South Africa in 1993 that he ran with his family until he moved to the USA with his American wife in 1996. He started his present business in the basement of his home.

He became an American citizen in 2004 and now has three children ages one, three, and six.

Johan says that there is nothing easy about starting a business in America. Nevertheless, he believes that there are virtually unlimited possibilities for an entrepreneur. It is such a huge market compared to where he started in South Africa. However, the competition is fierce and requires one to be on his toes every moment.

Marvin: Johan, how large is your facility and how many employees do you have?
Johan: The company moved into a 3,000 square foot storefront at the end of 2004, but the business is growing fast and will need to take up more of the building by the end of this year. We presently have four employees.

MM: What is your principal business?
JS: My company is a distributor of more than 2,000 line items including components, kits, tools, books, and oscilloscopes.

MM: What are your most popular products? Who are your customers for these items?
JS: We sell many camera modules with digital outputs that are used in robotic applications. Our 20-second voice recorder/play back modules sell well. These often end up in museum displays. Our low cost PIR modules are also very popular. Small manufacturers of Halloween props use many of these. We also have a range of low-cost microcontroller programmers that are popular with hobbyists. We've added numerous products from Velleman in the past two years such as Velleman soldering stations, oscilloscopes, multimeters, kits, tools, etc.

MM: Is there a newly developed product ready for release?
JS: We are introducing a range of digital video recorders (DVRs) customized for different applications such as door phone cams, taxi cams, vehicle black boxes, and slow motion capture, etc.

MM: Finally, please describe the day-to-day operation of your business.
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Power (max)	90W	108W	108W

Only $199.00 Each!

Details at Web Site > Test Equipment > Power Supplies

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- Ceramic heating element for more accurate temp control
- Temp control knob in F(392° to 896°) & C(200° to 489°)
- 3-prong grounded power cord/static safe tip
- Seperate heavy duty iron stand
- Replaceable iron/easy disconnect
- Extra tips etc. shown at web site

Rapid Heat Up!

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***Also* Available w/Digital Display & MicroProcessor Controller**

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Details at Web Site

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Item# **CSITWZ-STATION**

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- 2 channels 2 traces
- 20MHz Bandwidth
- Z axis (intensity modulation)
- TV video sync filter
- Component test function
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- Sensitivity: 5mV-20V/div
- Bandwidth: DC: DC-20MHz / AC: 10Hz-20MHz
- Horizontal Deflection Sweep Mode: AUTO, NORM
- Sweep Time: 0.2us-0.5s/div

Details at Web Site

> Test Equipment > Oscilloscopes/Outstanding Prices

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The heater and air control system are built-in and adjusted by the simple touch of the front keypad for precise settings. Temperature range is from 100°C to 480°C / 212°F to 896°F, and the entire unit will enter a temperature drop state after 15 minutes of non-use for safety and to eliminate excessive wear.

Item# **CSI825A++**

- CPU Controlled
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- 15-Minute Stand-By temperature "sleep" mode
- Power:110/120 VAC, 320 W maximum

Details at Web Site

> Soldering Equipment & Supplies

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- Measurement Rate: Slow, Medium, Fast: 2,10 or 20
- Basic Accuracy of 0.05%
- Stores up to 9 setups in memory
- Equivalent Circuit: Series or Parallel
- Measurement Modes: Auto, R+Q, L+Q, C+D, C+R
- Remote over RS-232C & GPIB/Handler Interface
- Parameters Displayed: Value, Deviation, %Deviation or Bin Number.
- Test Frequencys: 100Hz, 120Hz, 1kHz, 10kHz, 100kHz

$1499.00!

Item# **PROTEK 9216A**

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Dual Output DC Bench Power Supplies

High stability digital read-out bench power supplies featuring constant voltage and current outputs. Short-circuit and current limiting protection is provided. SMT PC boards and a built-in cooling fan help ensure reliable performance and long life.

As Low As **$99.50!**

- Source Effect: $5x10^{-4}$=2mV
- Load Effect: $5x10^{-4}$=2mV
- Ripple Coefficient:: <250uV
- Stepped Current: 30mA +/- 1mA

HOT ITEM!

*All 3 Models have a **1A/5VDC Fixed Output** on the rear panel*

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CSI5003X5: 0-50v/0-3amp 1-4: **$114.95** 5+: **$109.00**

CSI3005X5: 0-30v/0-5amp 1-4: **$119.00** 5+: **$114.00**

Details at Web Site > Test Equipment > Power Supplies

Triple Output Bench Power Supplies

with Large LCD Displays

- Output: 0-30VDC x 2 @ 3 or 5 Amps & 1ea. fixed output @ 5VDC@3A
- Source Effect: $5x10^{-4}$=2mV
- Load Effect: $5x10^{-4}$=2mV
- Ripple Coefficient: <250uV
- Stepped Current: 30mA +/- 1mA
- Input Voltage: 110VAC

CSI3003X3: 0-30VDCx2 @3A **$188.00** 5+: **$183.00**

CSI3005XIII: 0-30VDCx2 @5A **$239.00** 5+: **$229.00**

Details at Web Site > Test Equipment > Power Supplies

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- 200/100/60 MHz Bandwidth
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Details at Web Site > Test Equipment > Instek Test Equipment

Stepper Motors

Part #:	Motor Frame Size:	Holding Torque:	Price:
42BYGH404	NEMA 17	3.4kg.cm/47oz.in	$17.95
57BYGH207	NEMA 23	8kg.cm/111oz.in	$24.95
57BYGH303	NEMA 23	15kg.cm/208oz.in	$29.95
57BYGH405	NEMA 23	20kg.cm/277oz.in	$34.95
85BYGH350B-03	NEMA 34	48kg.in/665oz.in	$79.95
85BYGH350C-03	NEMA 34	63kg.cm/874oz.in	$119.95

Stepper Motor Controllers: 2 Phase Microstepping Stepper Motor Driver (Bi-polar & Unipolar Motors)

Part #:	Dimensions:	MicroStep:	Price:
XCW220	100mm x 61mm x 19mm	1(200), 1/2(400), 1/4(800), 1/8(1600)	$39.95
CW220	99mm x 65mm x 30mm	1/2(400), 1/8(1600)	$49.95
CW230	115mm x 72mm x 32mm	1(200), 1/2(400), 1/4(800), 1/8(1600), 1/16(3200), 1/32(6400), 1/64(12800)	$59.95
CW250	140mm x 94mm x 45mm	1(200), 1/2(400), 1/8(1600)	$69.95
CW860	147mm x 97mm x 30mm	1(200), 1/2(400), 1/4(800), 1/8(1600), 1/16(3200), 1/32(6400), 1/64(12800), 128(25600), 1/5(1000), 1/10(2000), 1/25(5000), 1/50(10000), 1/125(25000), 1/250(50000)	$119.95

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PC based Digital Storage Oscilloscope, 200MHz 5GS/s equiv. sampling USB interface

Convert any PC with USB interface to a high performance Digital Storage Oscilloscope. This is a sophisticated PC basedscope adaptor providing performance compatible to mid/high level stand alone products costing much more! Comes with two probes.

Details & Software Download at Web Site

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> Test Equipment > Oscilloscopes/Outstanding Prices

Item# 200DSO Only $819.00

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Details at Web Site

New Lower Price $1399.00

> Soldering Equipment & Supplies

Item# CSI-IR1

3-1/2 Digit LCD Panel Meter (enhanced version)

The PM-128E is an enhanced version of our best selling PM-128A. The E version can be set to work with either a 5VDC or 9VDC power source, will perform with either a common ground or an isoalted ground, and is supplied with easy to use jumper points so the end user can easily set the measurement range required.

Details at Web Site

> Panel Meters > Digital Panel Meters

$12.25 Quantity Price Breaks at website!

Item# PM-128E

Soldering Station w/Iron & SMD Hot Tweezers

- Electrostatic discharge safe design with grounding measure
- Tweezers directly applies heat to components being repaired while avoiding nearby components
- Suitable for crowded circuit boards
- 24V output voltage to ensure safety of user and protect soldered components on board

Details at Web Site

Item# CSI-950+ $59.00

> Soldering Equipment & Supplies > Soldering Stations

Additional Panel Meters on Web Site!

Jumbo LCD 9V Independent Ground Panel Meter

The PM-1028A is designed to run off of a 9V (7-11V) independent power source. The figure height is 21mm. High quality SMT construction provides high reliability and the decimal point selection is conveniently done by wire jumpers. The panel meter implements dual slope integration A-D conversion measuring methods.

Details at Web Site

> Panel Meters > Digital Panel Meters

Item# PM-1028A

$12.95 Quantity Price Breaks at website!

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The CX-102 series of digital panel meters have high reliability, good quality and fine workmanship. They can be used for a variety of applications and are competitively priced. Their unmatched performance make these 3-1/2 digit LED panel meters the first choice for applications that require instrumentation.

Details at Web Site

> Panel Meters > Digital Panel Meters

Item# CX102B

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